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Summary of Audit Performance Measurement of SO2, NO2, CO, Sulfate, Nitrate, Lead, Hi-Vol Flow Rate

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Summary of Audit Performance

Measurement of SO_2, NO_2, CO, Sulfate, Nitrate, Lead, Hi-Vol Flow Rate — 1977

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The report summarizes the results of the quality assurance audits for the period from October 1976 through December 1977. Pollutants for which audits were conducted and results reported are SO$_2$, NO$_2$, sulfate, nitrate, lead, and hi vol flow rate. The operation of the EPA audit program is also described.

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SUMMARY OF AUDIT PERFORMANCE: MEASUREMENT OF SO_2, NO_2, CO, SULFATE, NITRATE, LEAD, HI-VOL FLOW RATE

1977

by

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ABSTRACT

The Quality Assurance Branch of the Environmental Monitoring and Support Laboratory, Research Triangle Park, North Carolina, conducts an ambient air audit program. Measurement principles for sulfur dioxide, nitrogen dioxide, carbon monoxide, sulfate-nitrate, and lead are audited on a semiannual basis. Blind samples, the concentrations of which are known only to the EPA, are sent to the participating laboratories. Hi-Vol sampler flow rate audits are conducted annually using a modified orifice. The analytical results are returned to the Quality Assurance Branch for evaluation. After processing, an individual report is returned to each participant.

This report contains a summary of audit results obtained during October-December 1976 and all of calendar year 1977.

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SECTION 1

INTRODUCTION

Since 1972 the Environmental Protection Agency (EPA) has been engaged in a Performance Audit program of various monitoring groups throughout the United States and in several foreign countries. The audit program is only one part of an overall quality assurance program, so the results should not be construed as an absolute indicator of data quality. Used along with information obtained from an internal quality control program, however, the conclusions can be quite meaningful.

The purposes of the audit program are twofold. The first, from a participant standpoint, is most important. Agencies are furnished a means of rapid self-evaluation of the specific operation under study. The second objective of the program is to provide EPA with a continuing index of the validity of data being reported to air quality data banks.

The program is being coordinated through the 10 EPA Regional Offices (RO) by the Quality Assurance Branch (QAB) of the Environmental Monitoring and Support Laboratory (EMSL), Environmental Research Center, Research Triangle Park, North Carolina 27711. Comments, questions, or applications to participate in the program should be sent to the above address.

This publication is the second of a continuing series of yearly summary reports. The document covers the period from October 1976 through December 1977.

Users of the information contained in this report should take note of some limitations imposed in gathering the data. With the exception of the audit for carbon monoxide (CO), the surveys checked only a portion of the entire system. The sulfur dioxide (SO_2), nitrogen dioxide (NO_2), sulfate-nitrate ($SO_4^=$-NO_3^-), and lead (Pb) surveys examined only the analytical portion of the system. The Hi-Vol audit checked only the flow rate portion of the method. No restrictions were placed on the methodology used by the participants (other than that the method used had to be compatible with the audit samples). However, to the extent possible, the various methods used were documented.

The following sections include discussions of the program operation, descriptions of the audit materials, the statistical approach used to analyze the data, and the results. The Results Section includes data from October 1976-December 1977. The appendix contains the raw data of the audit sample analysis.

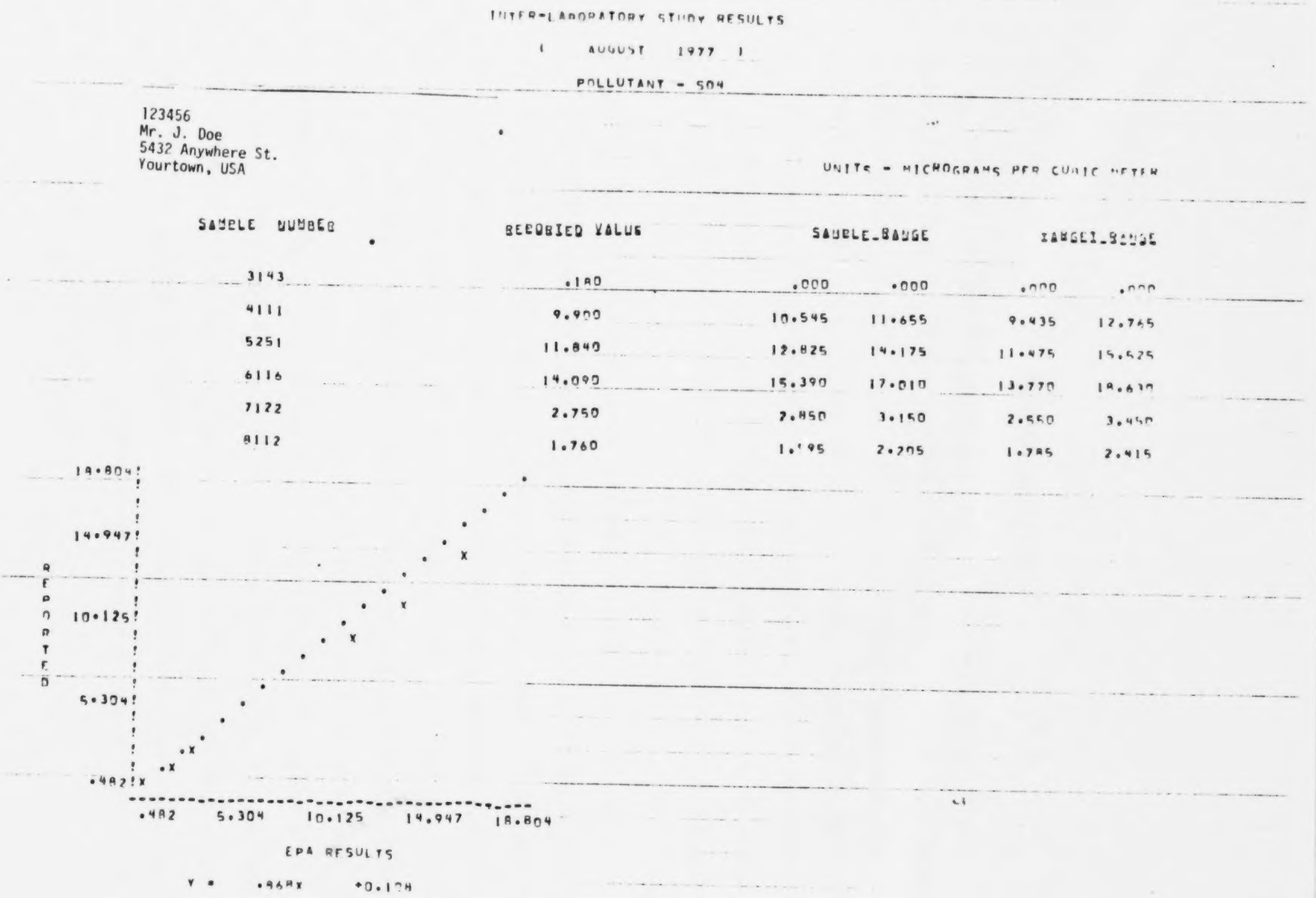
SECTION 2

PROGRAM COORDINATION

Participants in the audits were selected by the Regional Quality Control Coordinator in each of the 10 Regions. Once a potential participant has received audit samples for a particular pollutant, he is automatically notified of subsequent surveys for that pollutant. Additional participants are obtained through individual requests and through notification in the Journal of the Air Pollution Control Association. Participants are assigned an identification number which remains with the agency throughout all audits for all pollutants.

After the audit roster is completed for a particular survey, instructional materials and unknown samples are mailed. The participants are allowed 5 to 6 weeks in which to return their results. After these results are entered into a data bank, individual reports are returned to the participants. This report indicates the acceptable ranges for each sample as well as the value reported by the agency. Figure 1 is an example of an individual report for $SO_4^=$.

In order to determine whether incorrect results are due to inherent problems with a laboratory procedure or to just a "single event", recheck samples are sent to laboratories whose results do not meet certain criteria. Thus, by having a second chance to analyze a set of samples, real deficiencies can be distinguished from one-time problems.



INTER-LABORATORY STUDY RESULTS

(AUGUST 1977)

POLLUTANT - SO4

123456
Mr. J. Doe
5432 Anywhere St.
Yourtown, USA

UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER	REPORTED VALUE	SAMPLE_RANGE		TARGET_RANGE	
3143	.180	.000	.000	.000	.000
4111	9.900	10.545	11.655	9.435	12.765
5251	11.840	12.825	14.175	11.475	15.525
6116	14.090	15.390	17.010	13.770	18.630
7122	2.750	2.850	3.150	2.550	3.450
8112	1.760	1.[illegible]95	2.205	1.785	2.415

18.804
14.947
10.125
5.304
.482
REPORTED
.482
5.304
10.125
14.947
18.804
EPA RESULTS

Y = .968X +0.128

Figure 1. Example of individual report.

SECTION 3

STATISTICAL APPROACH

Of primary concern at the onset of the program was the establishment of some type of acceptance criteria to enable participants to judge their performance. Initially, there was little guidance, and the choices of acceptable limits were somewhat arbitrary. As more data have been gathered through the audit program, more realistic acceptance limits have been set.

For convenience, two acceptable ranges have been defined. The Sample Range contains variability attributable to the sample material. This estimation was based on the repeated analysis of several samples from each concentration range by one laboratory. Using the precision of the set of samples under consideration plus past data from similar samples, the Sample Ranges were chosen. The Sample Ranges should be goals of each agency; it is not reasonable to expect all laboratories to fall within these ranges on any given analysis. However, falling within these ranges repeatedly indicates a laboratory with excellent precision and accuracy. Falling outside the Sample Ranges does not necessarily indicate problems.

The Target Range has been constructed to include sample variability and interlaboratory variability. A laboratory falling outside the Sample Range but within the Target Range should feel comfortable with the results. If, however, the results fall outside the Target Range, the accuracy of the analysis should be considered suspect. The Target Range is based in part on past performance of all participants. The percent difference between the reported results and the true value (result determined by QAB) was established for past surveys. Using this percent difference for all samples over all surveys, an average difference was determined. This average difference was used to calculate the Target Ranges.

When evaluating results based on the acceptable ranges, one must take into consideration the uses of the data. For some purposes the Sample Range may be too wide; for other uses the Target Range may be too narrow. Thus, judgment should be excercised whenever comparing ranges with results.

A preferable method of evaluating performance "after the fact" is to compare individual results with the respective tables entitled "Absolute Percent Difference" found in the Results Section. These tables are frequency distribution tables of the percent difference between EPA and reported results. The relationship of individual performance to the overall study performance can be determined using these tables.

Two outlier tests were used as part of the overall analysis and to screen the data for further analysis. The first test was used to screen results that were grossly in error. To be eliminated from further analysis, a laboratory had to report all samples outside the Target Ranges for the respective pollutants. These data appear only in the Appendix and are marked with an asterisk (*). No further statistical analyses in this report contain these data. Data appearing in table columns labeled "All Data", or containing no specific designation, are results subjected to the first test.

A second outlier test, using a standard technique was also used.

Depending upon the number of results for each concentration a factor, ranging from 2.1 for 20 samples to 3.3 for 300 samples, was chosen. This factor was multiplied by the standard deviation of the sample as determined from the participant results. Results outside the range determined by the expression [(factor) x (standard deviation)] ± study mean were identified as outliers. These data are identified in the "Outliers Removed" columns of selected tables.

Several summaries have been used to condense the large amounts of data into a more manageable form. The tables in the Appendix are sequential listings of all data by sample concentration for each audit. Statistical summaries of the sequentially listed data are presented.

SECTION 4

AUDIT MATERIALS

AMBIENT SULFUR DIOXIDE SAMPLES

The commercially produced sample material consisted of freeze-dried mixtures of sodium sulfite and potassium tetrachloromercurate (TCM) contained in 5-ml glass vials with inert screw cap closures or in sealed glass ampoules. Sets of samples were comprised of five vials/ampoules containing approximately 4 to 54 μg of SO_2 equivalent per container. Initially, vials were chosen in place of ampoules to facilitate quantitative transfer of the contents. Difficulty had been experienced in transferring powder from the small ampoules due to the surface tension. However, because sample decay appeared to be a problem, use of ampoules was reinstated. The samples were placed in freezers immediately upon receipt with the expectation that a low temperature would preserve the integrity of the material. Initial EPA analyses were performed immediately after receipt. Subsequent reanalyses of the samples after several months demonstrated that freezing did not completely stabilize the sulfite content in that the SO_2 levels continued to gradually decline. Subsequent analyses of the samples have demonstrated that, while the decay is not completely eliminated, the rate has been reduced substantially. The analyses were performed by the reference method for the determination of SO_2 in the atmosphere (pararosaniline method)(1). The sample, when dissolved in 0.04 N potassium tetrachloromercurate (TCM) forms a dichlorosulfitomercurate complex. The complex is reacted with pararosaniline and formaldehyde to form intensely colored pararosaniline sulfonic acid. The absorbance of the solution is measured spectrophotometrically at 548 nm.

Ten samples from each concentration were analyzed. Table 1 lists the results of these analyses. The values contained in Table 1 are those used in determining the acceptable ranges reported to participants. The values listed are based on the assumption that the sample was collected in 50 ml of absorbing reagent and the total sample air volume was 300 ℓ.

TABLE 1. MEAN AND STANDARD DEVIATION OF SO_2 ACCEPTANCE ANALYSIS ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
SO_2 Audit 1176	19.13	0.87	43.03	1.07	73.37	2.40	102.97	3.22	149.03	2.04
SO_2 Audit 0477	21.90	1.33	48.23	1.33	80.17	1.30	114.70	3.03	155.40	2.27
SO_2 Audit 1077	13.60	0.50	56.20	1.31	93.73	2.23	93.73	2.23	179.07	1.00

AMBIENT NITROGEN DIOXIDE SAMPLES

The commercially produced samples consisted of 4 ml of aqueous sodium nitrite in 5-ml glass vials with inert screw cap closures. A set of samples consisted of five vials. The samples, when mixed with absorbing reagent, simulated ambient samples ranging from 0.12 to 0.87 μg/ml.

EPA analysis of 10 samples from each concentration was performed using a candidate method for the determination of NO_2 in ambient air (2). Measurements were made on a Varian Model 635 UV-Vis spectrophotometer at 540 nm. Aqueous calibration standards were prepared to encompass a linear range from

0 to 1.6 μg/ml of NO_2. Table 2 lists the results of these analyses. The values contained in Table 2 are those used in determining the acceptable ranges reported to participants. The values listed are based on the assumption that the sample was collected in 50 ml of absorbing reagent.

TABLE 2. MEAN AND STANDARD DEVIATION OF NO_2 ACCEPTANCE ANALYSIS (μg/ml)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
NO_2 Audit 1276	0.12	0.01	0.18	0.01	0.33	0.01	0.54	0.05	0.87	0.02
NO_2 Audit 0677	0.12	0.02	0.24	0.02	0.24	0.02	0.38	0.02	0.69	0.04
NO_2 Audit 1277	0.18	0.04	0.31	0.03	0.50	0.02	0.50	0.02	0.87	0.03

AMBIENT CARBON MONOXIDE SAMPLES

The samples consisted of commercially produced mixtures of CO and artificial air. Mixtures also contained approximately 2 ppm methane and 350 ppm of CO_2. Specially treated aluminum cylinders were used to improve gas stability. Sample concentrations ranged from approximately 3 to 40 ppm of CO. Each participant received a set of three cylinders, one from each concentration level.

Analysis by EPA of cylinders from each concentration was performed using a Bendix Model 8501 NDIR analyzer. National Bureau of Standards SRM gases were used as the reference standards. Three SRM's at nominal concentrations of 9, 46, and 95 ppm CO were used as the primary reference gases.

Ten samples from each concentration were analyzed. Table 3 lists the results of these analyses. The values contained in Table 3 are those used in determining the acceptable ranges reported to participants.

TABLE 3. MEAN AND STANDARD DEVIATION OF CO ACCEPTANCE ANALYSIS (ppm)

	Conc. 1		Conc. 2		Conc. 3	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
CO Audit - 1076	4.51	0.09	20.89	0.09	40.14	0.04
CO Audit - 0377	3.38	0.02	15.87	0.04	31.72	0.04
CO Audit - 0977	4.79	0.04	16.59	0.02	36.00	0.05

SULFATE-NITRATE SAMPLES

The commercially prepared samples consisted of 19 mm by 20 cm (0.75 x 8 in.) fiberglass filter strips with depositions of potassium sulfate (K_2SO_4) and lead nitrate (KNO_3). Filter strip sample sets were comprised of combinations of differing $SO_4^=$ and NO_3^- concentrations. Each strip was packaged in a plastic envelope. The concentration of sulfate ranged from 0 (blank) to 40 $\mu g/m^3$. Nitrate concentrations ranged from 0 (blank) to 15 $\mu g/m^3$. Concentrations were calculated assuming that the samples were collected on a 20 by 25.4 cm (8 x 10 in.) filter with a total air volume of 2000 m^3.

It was felt that the gravimetric preparation of the solution deposited onto the filter strips was more accurate than analysis using existing procedures. Thus, the values accepted as "true values" are the vendor certifications. Verification analyses ensured that the accuracy and precision of the samples were acceptable. Table 4 lists the concentrations of the samples used during the audit.

TABLE 4. SULFATE AND NITRATE SAMPLE VALUES ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3
SO_4-NO_3 Audit 1076	0.00	0.00	1.20	0.54	2.99	3.45	10.42	9.58	-	-	-	-
SO_4-NO_3 Audit 0277	4.47	1.94	15.63	5.17	21.16	7.38	24.87	10.92	-	-	-	-
SO_4-NO_3 Audit 0877	0.00	0.00	2.10	0.72	3.00	1.32	11.11	4.80	13.52	6.00	16.20	7.81

LEAD SAMPLES

The commercially prepared samples consisted of 19 mm by 20 cm (0.75 by 8 in.) fiberglass filter strips with depositions of lead nitrate ($Pb(NO_3)_2$). Filter strip sample sets were comprised of combinations of differing lead concentrations. Each strip was packaged in a plastic envelope. The concentrations of lead ranged from 0 (blank) to approximately 12 $\mu g/m^3$. Concentrations were calculated assuming the samples were collected on a 20 by 25.4 cm (8 x 10 in.) filter with total air volume of 2000 m^3.

It was felt that the gravimetric preparation of the solution deposited onto the filter strips was more accurate than analysis using existing procedures. Thus, the values accepted as "true values" are the vendor certifications. Verification analyses ensured that the accuracy and precision of the samples were acceptable. Table 5 lists the concentrations of the samples used during the audit.

TABLE 5. LEAD SAMPLE VALUES (μg/m^3)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	$\bar{x}$	s*	$\bar{x}$	s*	$\bar{x}$	s*	$\bar{x}$	s*	$\bar{x}$	s*	$\bar{x}$	s*
Pb Audit 0877	0.00	-	1.80	.01	4.05	.01	6.60	.01	8.40	.01	11.40	.01

*Based on weight of applied chemical

HI-VOL REFERENCE FLOW DEVICE (ReF)

One ReF was supplied to each participating agency. The organization was instructed to check as many Hi-Vol sampling units as feasible within the alotted time. The auditing unit received by each laboratory consisted of a modified orifice (ReF), wind deflector, manometer, and resistance plates (to change flow rates).

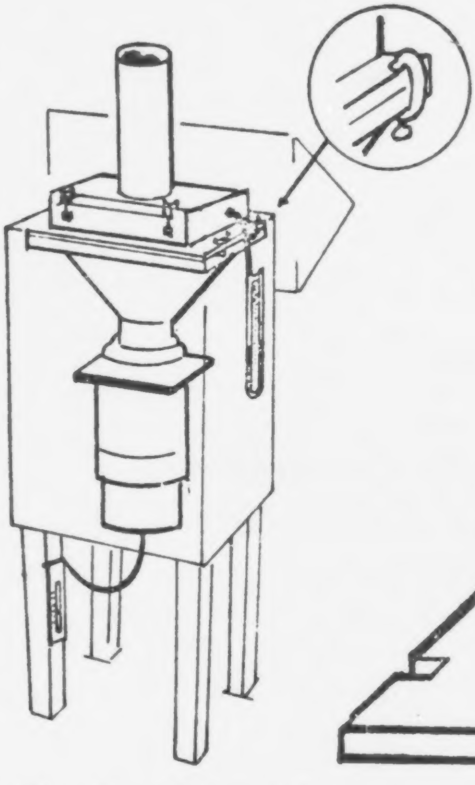


Fig. 2. ReF mounted on Hi-Vol sampler.

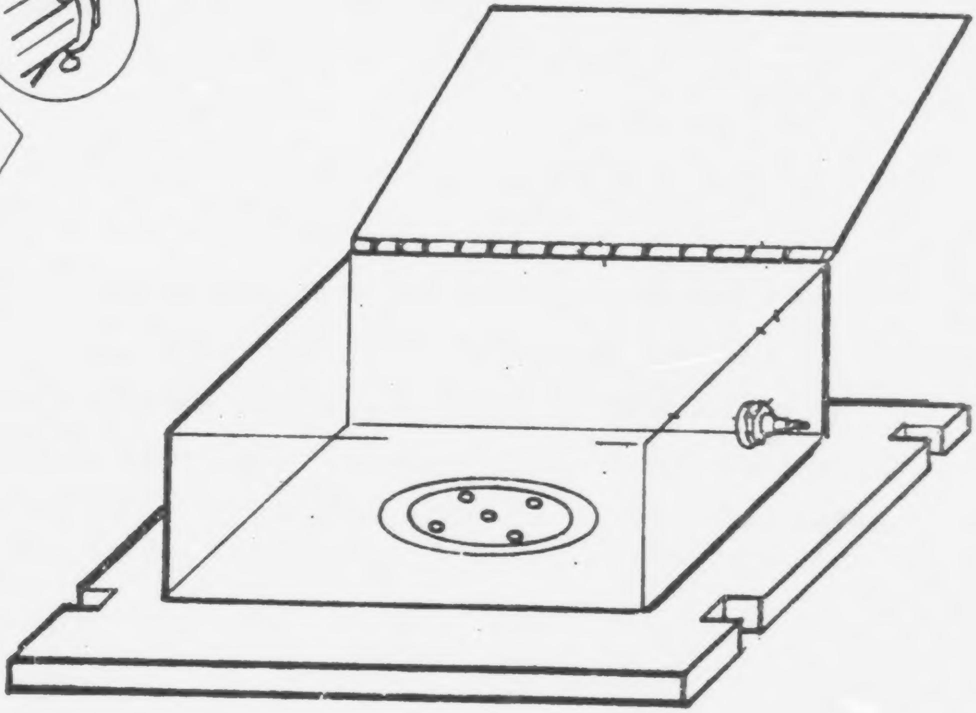


Fig. 3. ReF with resistance plate.

When auditing the flow rate of a Hi-Vol sampler, the ReF was mounted on top of the sampler, replacing the filter face plate (see Figure 2). The wind deflector was necessary to prevent fluctuation in the readings due to wind flowing across the orifice. The manometer was used to measure the pressure drop across the orifice. The resistance plates, when inserted into the ReF, simulated various filter loading conditions (see Figure 3).

By calibrating each ReF with a positive displacement meter (Roots meter), and by measuring pressure drops and temperatures, an individual calibration curve in the form of an orifice equation could be derived. The equation shown below was used to determine "K" orifice constant for each unit.

$$Q_1 = AYC \sqrt{\frac{\Delta P \; T_1}{P_1}}$$

where:

Q_1 = volumetric flow at conditions of T_1 and P_1 (m^3/min)

A = area of orifice (in^2)

Y = expansion factor

C = orifice coefficient

ΔP = pressure drop across orifice (in. H_2O)

P_1 = upstream pressure (barometric pressure -mm Hg)

T_1 = upstream temperature (ambient temperature - K)

Because A is constant for a given orifice, and Y and C are essentially constant over the flow range in question, a new orifice constant K was defined as:

$$K = AYC$$

Thus, the orifice equation becomes:

$$Q_1 = K \sqrt{\frac{\Delta P \ T_1}{P_1}} \quad .$$

During calibration of the ReF, Q_1, ΔP, T_1, and P_1 were measured. The constant K is then determined by regressing a series of Q_1 measurements onto the square root of the values under the radical.

During an audit, field personnel measure ΔP, T_1, and P_1. By knowing K, the "true flow" can be calculated. This flow is compared with the flow rate as measured by the Hi-Vol sensor to determine the accuracy of the flow rate measurements.

SECTION 5

RESULTS

AMBIENT SULFUR DIOXIDE

Participant Characteristics

Sulfur dioxide study number 1176 began in November 1976. Out of 184 sample sets requested by participants, 151 sets of data were returned for a response rate of 82%. Study number 0477 began in April 1977. Out of 173 sample sets requested, 140 sets of data were returned for a response rate of 81%. Study 1077 began in October 1977. Out of 166 sample sets requested, 126 sets of data were returned for a response rate of 76%.

Table 6 indicates the monitoring agency type distribution.

TABLE 6. SO_2 AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
SO_2 Audit - 1176						
Agencies Requesting Samples	1	9	61	85	27	184
Agencies Returning Data	1	7	51	75	17	151
SO_2 Audit - 0477						
Agencies Requesting Samples	1	8	57	78	29	173
Agencies Returning Data	1	8	49	62	20	140
SO_2 Audit - 1077						
Agencies Requesting Samples	1	8	56	73	28	166
Agencies Returning Data	1	5	46	54	20	126

Methods used to analyze the samples were grouped into three broad categories: manual pararosaniline, automated pararosaniline, and other. Table 7 lists the analytical methods used and the number of respondents using the method.

TABLE 7. SO_2 ANALYTICAL METHODS

Method	Number Agencies Using Method		
	Audit 1176	Audit 0477	Audit 1077
Manual Para.	118	107	96
Automated Para.	30	31	27
Other	3	2	3

It should be noted that laboratories tend to define the method used in very general terms. Thus, an agency reporting to have used the manual pararosaniline technique may not have used the method exactly as it appears in 40 CFR 50.11 (1).

Acceptable Ranges

As described in a previous section, two ranges were used as one means of judging performance. The Sample Ranges and Target Ranges for the studies are listed in Table 8. The ranges apply to sample values in increasing concentration.

The Sample Ranges for Audit 1176 were determined using the method described in the first document in this series (3). Sample Ranges for Audit 0477 were determined using the method described in the Statistical Approach section of this report. The Sample Ranges, as used in Audit 1077, were not ranges in the sense used above, but were indications of the precision with

TABLE 8. SO_2 SAMPLE AND TARGET RANGES

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5
SO_2 Audit - 1176					
Sample Range	± 9.8%	± 5.4%	± 7.0%	± 4.7%	± 2.9%
Target Range	± 20%	± 20%	± 20%	± 20%	± 20%
SO_2 Audit - 0477					
Sample Range	± 10%	± 10%	± 10%	± 10%	± 10%
Target Range	± 20%	± 20%	± 20%	± 20%	± 20%
SO_2 Audit - 1077					
Sample Range	± 3.7%	± 2.3%	± 2.4%	± 2.4%	± 0.6%
Target Range	± 20%	± 20%	± 20%	± 20%	± 20%

which QAB analyzed the samples. The percentages were the equivalent of one standard deviation from the mean. As explained previously, it was determined from earlier studies that the average percent difference between reported results and EPA determined values was ±20%. Thus, this value has been used for all Target Ranges.

Using the above criteria, a tabulation was made of the number of agencies reporting results within the ranges. For Audit 1176, 53 (35%) of the agencies reported all five results within the Target Ranges, while 20 (13%) of the laboratories reported all results outside these ranges. The corresponding figures for Audit 0477 showed 49 (35%) and 7 (5%), respectively. Audit 1077 showed 36 (29%) and 11 (9%), respectively. These results compare with previous audits in that 37% of the laboratories submitting results in Audit 0576 reported all samples within the Target

Ranges, while 10% reported all values outside the ranges. Figure 4 shows a running tally of the above values.

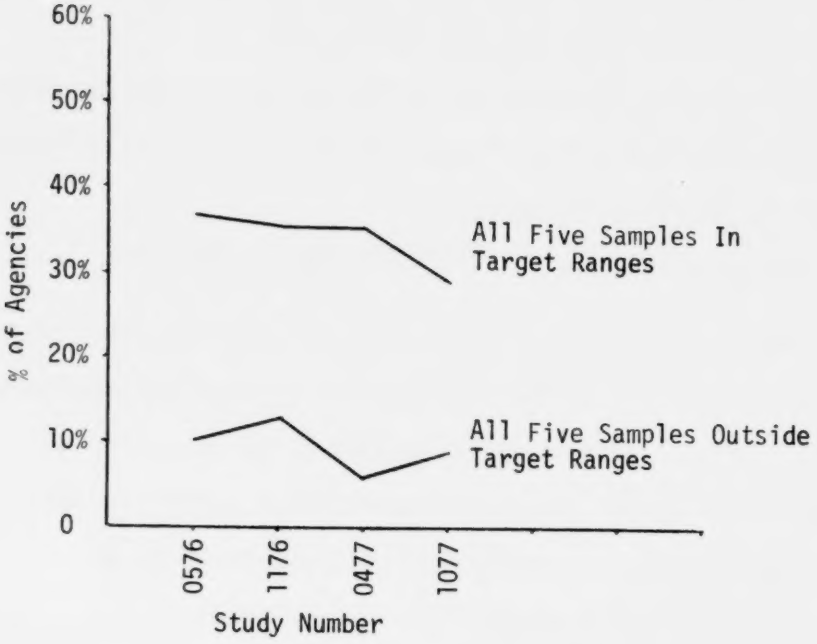


Figure 4. Plot of SO_2 Results (five samples within and outside Target Ranges).

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that the laboratories reporting all five results outside the Target Ranges (i.e., had all results greater than ±20% of the EPA values) would be removed from the data base and excluded from further evaluations. The Target Ranges are broad enough that, unless the determination is totally out of control, at least one value should fall within the ranges if the laboratory is performing similarly to most of the study population. Thus, if the agency is not performing in a similar manner, its data should not be included in the summaries.

The remainder of the discussion will be concerned with the reported results minus the data sets that met the exclusion criterion. These data points are marked in the Appendix by an asterisk (*).

Table 9 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following equation:

$$\text{Absolute Percent Difference} = \left|\frac{\text{Reported value - EPA value}}{\text{EPA value}}\right| \times 100 .$$

The frequency distribution was then constructed and appears below. For example, for audit 1175, 50% of the reported results for sample Concentration 1 were less than or equal to an absolute percent difference of 17.6%. It should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all the data is examined together regardless of its concentration.

The data in Table 9 are very useful for laboratories trying to determine their performance relative to other participants. For example, for Audit 0477, only 10% of the labs reporting results for Concentration 1 had a percent difference of 4.3% or less, while 50% of the laboratories reported a percent difference of 21.0% or less for the same concentration. The table also indicates the average percent difference for all laboratories for all samples. These are presented graphically in Figure 5 along with corresponding values from previous audits.

TABLE 9. SO_2 ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
SO_2 Audit - 1176									
Concentration 1	128	0.7	2.5	9.6	17.6	30.0	58.9	173.9	27.2
Concentration 2	133	0.5	2.4	6.2	10.8	16.6	32.6	448.0	18.0
Concentration 3	133	0.0	1.7	5.3	9.2	14.3	21.4	614.2	16.5
Concentration 4	132	0.5	2.9	6.8	10.4	15.3	24.0	871.1	23.6
Concentration 5	130	0.2	1.3	5.1	7.9	11.6	17.8	571.0	14.9
All Samples	656	0.0	2.2	6.3	10.6	16.3	35.5	871.1	20.0
SO_2 Audit - 0477									
Concentration 1	128	0.5	4.3	15.3	21.0	31.5	55.5	851.1	33.5
Concentration 2	132	0.0	2.2	5.6	10.3	18.2	31.6	75.8	15.1
Concentration 3	132	0.3	1.5	3.9	6.4	11.5	23.0	61.6	10.6
Concentration 4	131	0.0	0.6	3.1	4.8	9.3	17.2	43.9	8.4
Concentration 5	133	0.0	1.2	2.9	6.1	9.7	23.1	67.2	9.5
All Samples	656	0.0	1.5	4.1	8.6	16.3	32.3	851.1	15.3
SO_2 Audit - 1077									
Concentration 1	103	0.0	2.9	13.0	22.9	46.1	69.1	134.4	44.7
Concentration 2	111	0.2	2.1	4.6	8.5	13.4	34.7	715.5	20.8
Concentration 3	112	0.2	1.5	3.2	5.6	8.8	18.4	51.3	8.4
Concentration 4	111	0.2	0.6	2.7	5.3	8.4	17.4	89.1	8.4
Concentration 5	110	0.0	0.8	3.3	4.9	7.5	16.4	97.2	9.3
All Samples	547	0.0	1.4	3.7	6.8	13.3	39.8	715.5	17.9

All data received (with the exception of previously omitted data) were grouped according to concentration. The results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 10 and at the top of each listing in the Appendix do not include the data sets identified as outliers.

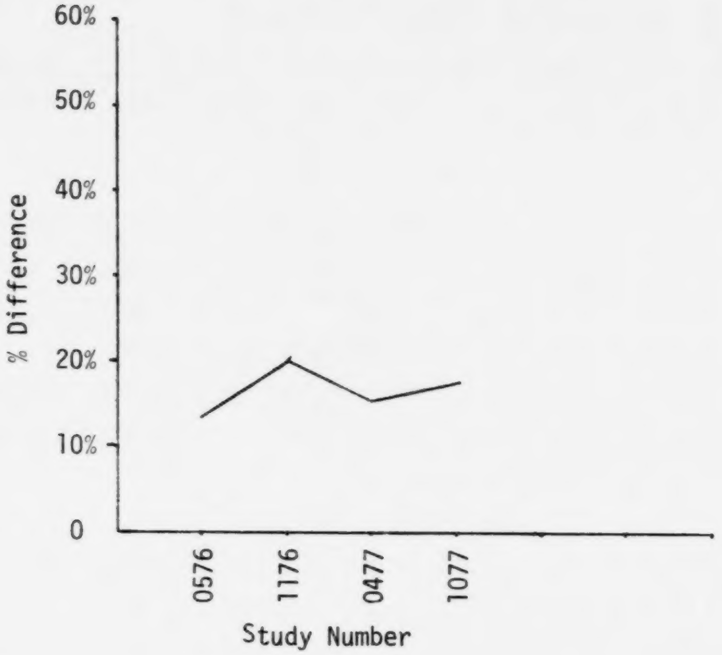


Figure 5. Plot of SO_2 absolute percent differences.

Table 10 lists summary statistics based on the reported data. The "Outliers Removed" columns contain data on which the outlier criterion was applied; all data which met the second criterion stated in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples.

An examination of Table 10 reveals that there are no apparent problems with bias (as indicated by "Accuracy"). For only one sample is the "Accuracy" figure greater than 10%. For all three audits the data are Normally distributed (Skewness, see foot note of table).

Each laboratory data set was plotted against the corresponding EPA data set, and the slope and intercept of the linear regression line were determined. For audit 1176, the mean of 132 slopes was 0.912 with a standard

TABLE 10. SO_2 SURVEY STATISTICS ($\mu g/m^3$)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed
SO_2 Audit - 1176										
Number	128	125	133	132	133	132	132	130	130	129
True value	19.1	19.1	43.0	43.0	73.4	73.4	103.0	103.0	149.0	149.0
Mean	17.5	16.8	45.7	44.3	80.9	77.5	123.1	112.7	163.0	156.6
Median	17.6	17.4	45.1	44.9	77.8	77.8	111.8	111.8	158.4	158.3
Range	52.2	36.5	225.5	63.1	484.1	93.5	950.2	191.3	999.1	250.0
Std. Dev.	7.6	6.1	18.6	8.5	40.4	11.7	89.8	18.4	77.6	23.4
Coef. Var.	43.1	36.0	40.8	19.2	50.0	15.1	73.0	16.3	47.6	14.9
Skewness[1]	1.1	-0.3	7.9	-0.5	9.9	0.5	8.2	2.5	9.6	-1.9
Accuracy[2]	-8.1	-9.2	4.9	4.4	6.0	6.0	8.6	8.6	6.3	6.2
SO_2 Audit - 0477										
Number	128	127	132	130	132	129	131	128	133	130
True value	21.9	21.9	48.2	48.2	80.2	80.2	114.7	114.7	155.4	155.4
Mean	29.4	18.9	45.3	45.8	77.8	78.2	115.2	114.1	158.6	159.6
Median	18.3	18.3	45.7	45.8	78.2	78.3	113.6	113.0	158.4	158.6
Range	207.2	44.6	60.0	51.5	83.5	62.0	86.1	75.0	177.7	101.0
Std. Dev.	18.2	7.1	9.6	8.8	12.1	10.5	13.9	12.1	22.2	17.8
Coef. Var.	89.0	37.5	21.2	19.2	15.5	13.4	12.1	10.6	14.0	11.2
Skewness[1]	8.7	0.9	-0.2	0.3	-0.7	-0.4	0.9	0.4	-0.9	0.1
Accuracy[2]	-16.4	-16.4	-5.2	-5.1	-2.5	-2.3	-0.1	-1.5	1.9	2.1
SO_2 Audit - 1077										
Number	103	102	111	110	112	110	111	108	110	106
True value	13.6	13.6	56.2	56.2	93.7	93.7	93.7	93.7	179.1	179.1
Mean	15.4	13.6	57.4	53.8	91.9	92.6	94.8	94.8	167.8	173.4
Median	13.1	13.1	54.6	54.6	91.8	92.4	94.3	94.3	172.9	172.9
Range	193.9	29.1	437.3	91.2	76.0	56.8	123.4	51.1	206.6	115.1
Std. Dev.	18.9	5.8	40.3	12.4	11.1	9.7	13.0	8.9	32.6	15.3
Coef. Var.	122.9	42.5	70.2	23.0	12.0	10.5	13.6	9.4	19.4	8.8
Skewness[1]	8.5	0.5	8.9	1.0	-0.9	-0.3	1.9	0.3	-3.5	-1.4
Accuracy[2]	-3.7	-3.7	-2.8	-2.0	-2.0	-1.4	0.6	0.6	-3.4	-3.4

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a normal distribution this value is near zero.

[2] Accuracy - $\frac{\text{Median - True value}}{\text{True value}} \times 100$

deviation of 0.209. The mean intercept was 3.93 with a standard deviation of 12.00. Audit 0477 had a mean slope of 0.944 with a standard deviation of 0.148. The mean intercept was 6.44 with a standard deviation of 10.75. Audit 1077 had a slope of 0.957 with a standard deviation of 0.241. The intercept was 6.02 with a standard deviation of 21.36. Figure 6 shows a graphical plot of these results.

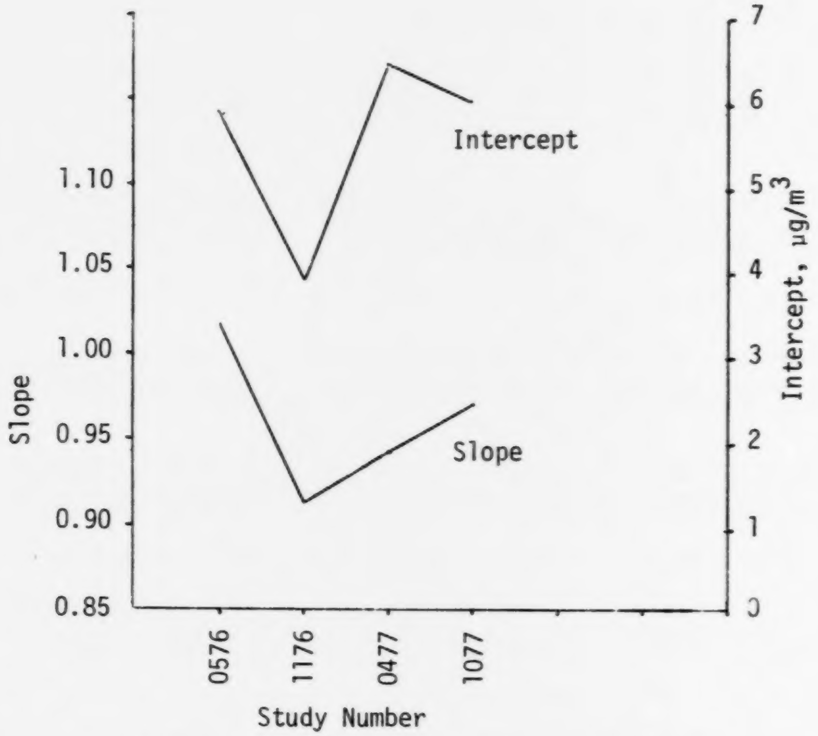


Figure 6. Plot of SO_2 slope and intercept.

Analytical Method Summary

A check was made to determine whether the data sets excluded from the summary were related to the method used for analysis (i.e., was any one method responsible for most of the data outliers). The following table (Table 11) resulted.

TABLE 11. SUMMARY OF SO_2 ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total Number Using Method	Number Identified as Outliers	Percent of Total as Outliers
		SO_2 Audit - 1176	
Pararosaniline-Manual	118	17	14%
Pararosaniline-Automated	30	3	10%
Other	3	-	-
		SO_2 Audit - 0477	
Pararosaniline-Manual	107	7	7%
Pararosaniline-Automated	31	-	-
Other	2	-	-
		SO_2 Audit - 1077	
Pararosaniline-Manual	96	11	11%
Pararosaniline-Automated	27	2	7%
Other	3	-	-

As can be seen, no one method contributed an unusually large portion of the outlier data.

To determine whether a particular analytical method produced biased results, Table 12 was developed. This table contains the mean and standard deviation of each sample concentration for each method used.

No pattern was established for the manual method in any of the audits, with the exception of 1176. In this audit, the lower values were lower than the "true values", while the higher concentrations were greater than the "true values". The same pattern held for the automated method for both 1176 and 0477

TABLE 12. MEAN AND STANDARD DEVIATION OF SO_2 RESULTS BY ANALYTICAL METHOD ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
SO_2 Audit - 1176										
Manual	17.5	7.6	43.9	9.2	77.2	12.5	121.0	91.0	154.2	25.3
Automated	15.7	5.2	45.3	5.0	78.4	9.2	113.9	11.3	164.3	13.0
Other	16.7	3.2	46.9	7.5	78.8	7.3	120.1	10.3	168.6	12.7
True value	19.1		43.0		73.4		103.0		149.0	
SO_2 Audit - 0477										
Manual	21.5	20.7	45.6	10.7	78.4	12.4	115.7	15.2	159.2	22.2
Automated	17.5	3.6	45.0	5.1	77.8	7.7	114.0	9.3	159.8	17.0
Other	8.7	10.7	35.6	0.2	47.8	24.1	108.5	2.1	110.9	55.0
True value	21.9		48.2		80.2		114.7		155.4	
SO_2 Audit - 1077										
Manual	15.9	12.8	51.9	13.4	89.0	14.8	93.1	16.1	162.4	39.6
Automated	13.2	4.7	72.6	81.9	96.7	8.9	95.8	14.6	179.6	17.1
Other	11.3	2.4	49.6	17.2	103.7	8.2	105.0	9.0	168.4	26.6
True value	13.6		56.2		93.7		93.7		179.1	

As would be expected, the automated method was more precise than the manual method. However, in many cases the "Other" category was more precise, as indicated by smaller standard deviations, than either the automated or manual method.

Recheck Program

Starting with audit 1176, a recheck program was begun. Any laboratory reporting at least three results that were greater than ±20% of the EPA values was sent a second set of samples. This procedure would distinguish between labs having chronic problems and those who just had a "bad day." For audit 1176, 34 laboratories received a second set of samples. Of the 24 groups returning data, 13 had corrected their problems to the extent that at least three samples fell within ±20% of the EPA values.

Twenty-three laboratories received recheck samples for audit 0477. Sixteen of these groups returned data, of which 14 had corrected their problems to the extent that at least three samples fell within ±20% of the EPA values. Fourteen agencies received recheck samples for audit 1077. Eight returned data, of which six had corrected their problem to the extent that at least three samples fell within ±20% of the EPA values.

Nine agencies receiving recheck samples did so in at least two of the above audits. Of these, four did not participate in the remaining audit. Thus, it appears that a small percentage of the agencies performing SO_2 analysis still have basic analytical problems. It also appears that many of the problems uncovered during the initial analysis were corrected before the recheck samples were received.

Summary

The SO_2 audit starting dates covered in this report ranged from November 1976 to October 1977. The number of participants varied from

126 to 184. Foreign, EPA, State, local, and private laboratories submitted data.

Three analytical methods were used. The majority of the laboratories in all three audits used the manual pararosaniline method. Approximately 25% of the laboratories used the automated pararosaniline procedure.

The overall results showed no bias of any practical significance between the reported and EPA values. The statistical distribution of each audit appeared to be normal.

As would be expected, the automated method proved to be more precise than the manual method. Neither method appeared to be more accurate than the other.

The average slopes (Reported vs. EPA) for each audit ranged from 0.912 to 0.957. The intercepts varied from 3.93 to 6.44 $\mu g/m^3$.

AMBIENT NITROGEN DIOXIDE

Participant Characteristics

Nitrogen dioxide audit number 1276 began in December 1976. Out of 130 sample sets requested by participants, 110 sets of data were returned for a response rate of 85%. Audit number 0677 began in June 1977. Out of 123 sample sets requested, 95 sets of data were returned for a response rate of 77%. Audit number 1277 began in December 1977. Out of 124 sample sets requested, 90 sets of data were returned for a response rate of 73%.

Table 13 indicates the monitoring agency type distribution.

TABLE 13. NO_2 AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
			NO_2 Audit - 1276			
Agencies Requesting Samples	2	11	47	57	13	130
Agencies Returning Samples	1	8	41	50	10	110
			NO_2 Audit - 0677			
Agencies Requesting Samples	1	9	41	60	12	123
Agencies Returning Samples	1	6	37	44	7	95
			NO_2 Audit - 1277			
Agencies Requesting Samples	1	9	41	58	15	124
Agencies Returning Samples	1	5	37	40	7	90

Methods used to analyze the samples were grouped into five broad categories. Table 14 lists the analytical methods used and the number of respondents using the method.

TABLE 14. NO_2 ANALYTICAL METHODS

Method	Number Agencies Using Method		
	Audit 1276	Audit 0677	Audit 1277
Saltzman-man.	3	4	4
Sodium Arsenite-man.	72	62	56
Sodium Arsenite-auto.	28	23	24
TGS - ANSA-man.	3	2	2
Other	4	4	4

It should be noted that agencies tend to define the analytical method used in very general terms. A laboratory reporting the use of the manual sodium arsenite procedure as the method of choice may have used that procedure with various modifications. Thus, Table 14 should be interpreted as 72 laboratories used a procedure approximating the manual sodium arsenite method during audit 1276.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means available for judging performance. The Sample Ranges and Target Ranges for NO_2 are listed in Table 15. The ranges apply to sample values in increasing concentration.

TABLE 15. NO_2 SAMPLE AND TARGET RANGES

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5
Sample Range	±10%	±10%	±10%	±10%	±10%
Target Range	±20%	±20%	±20%	±20%	±20%

Neither the Sample Ranges nor the Target Ranges were determined using the methods described under Statistical Approach. Both ranges were arbitrarily set at the values listed in Table 15. As more audits are conducted and more data becomes available, the ranges will be refined.

Using the above criteria, a tabulation was made of the number of agencies reporting results within the ranges. For audit 1276, a total of 61 (55%) agencies reported all five results within the Target Ranges, while 2 (2%) laboratories reported all results outside these ranges. The corresponding figures for audit 0677 showed 59 (62%) and 2 (2%), respectively. Audit 1277 showed 69 (77%) and 3 (3%), respectively. These results compare with previous audits in that 51% of the laboratories submitting results in study 0676 reported all samples within the Target Ranges, while 8% reported all values outside the ranges. Figure 7 shows a running plot of the above values.

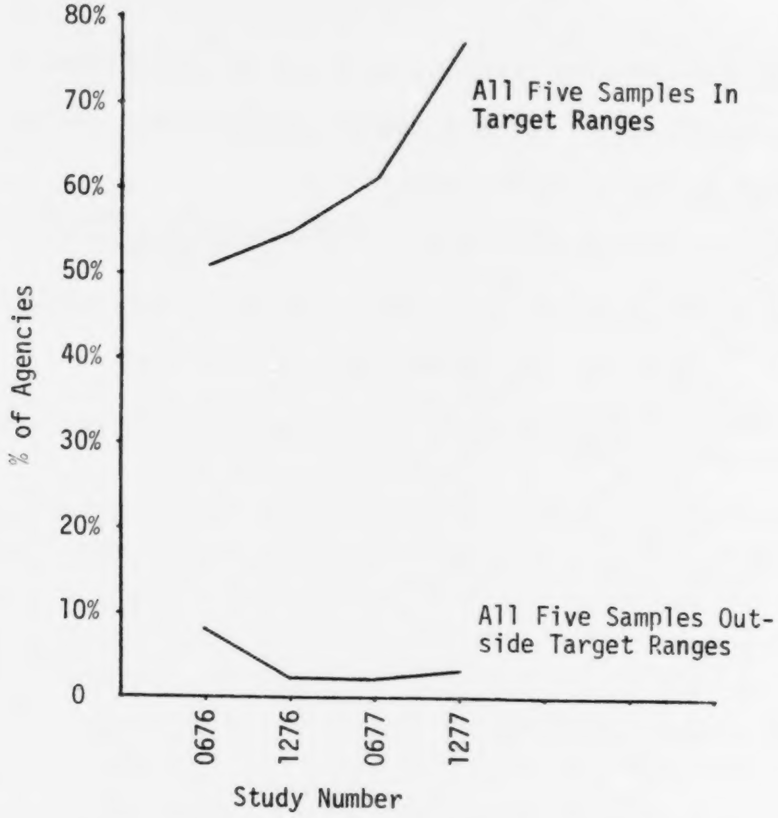


Figure 7. Plot of NO_2 results (five samples within and outside Target Ranges).

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that any laboratory not reporting at least one value within the Target Ranges would be considered an outlier. The Target Ranges are sufficiently broad that, unless the analysis is totally out of control, at least one value would fall within the ranges if the laboratory is performing similarly to most of the study population. Thus, if the agency is not performing in a similar manner, its data should not be included in the summaries. The remainder of this discussion will deal with the reported results minus the values identified as outliers. The values identified as outliers are noted in the Appendix by an asterisk (*).

Table 16 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{Absolute Percent Difference} = \left|\frac{\text{Reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears below. It

TABLE 16. NO_2 ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
					NO_2 Audit - 1276				
Conc. 1	106	0.0	0.8	5.0	8.3	16.7	30.8	80.0	15.3
Conc. 2	105	0.6	0.6	5.0	8.8	11.6	22.6	81.8	11.4
Conc. 3	108	0.0	0.9	2.4	4.9	7.4	16.6	32.2	7.1
Conc. 4	108	0.2	0.8	3.0	6.0	8.2	14.2	40.5	7.3
Conc. 5	107	0.0	0.5	1.7	3.0	6.3	13.8	34.1	5.4
All Samples	534	0.0	0.8	2.8	6.1	10.1	22.5	81.8	9.3
					NO_2 Audit - 0677				
Conc. 1	88	0.0	0.8	5.9	9.2	14.3	24.4	77.3	12.7
Conc. 2	91	0.0	0.8	3.4	5.5	9.2	16.4	82.4	8.5
Conc. 3	86	0.4	1.2	2.5	4.9	7.8	17.2	76.2	7.8
Conc. 4	92	0.0	0.5	2.1	3.4	6.9	15.1	74.9	7.8
Conc. 5	90	0.0	0.4	2.0	3.8	5.9	12.2	75.7	5.8
All Samples	448	0.0	0.8	2.9	5.0	9.2	17.6	82.4	8.5
					NO_2 Audit - 1277				
Conc. 1	84	0.0	0.6	2.2	5.0	7.7	22.1	58.6	9.0
Conc. 2	86	0.3	1.3	3.5	4.5	7.4	15.8	35.7	7.1
Conc. 3	87	0.2	1.8	3.4	4.8	6.8	12.5	19.4	6.0
Conc. 4	86	0.0	1.0	2.2	3.4	5.4	11.9	20.6	5.0
Conc. 5	88	0.1	0.9	1.8	3.1	5.2	9.2	96.1	5.3
All Samples	431	0.0	1.0	2.6	4.2	6.6	13.7	96.1	6.5

should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all the data is examined together, regardless of the concentration.

Table 16 is very useful for laboratories trying to determine their performance relative to the other participants. For example, in audit 1276, only 10% of the labs reporting results for Concentration 1 had a percent difference of 0.8% or less, while 50% of the laboratories reported a percent difference of 8.3% or less for the same concentration. The table also indicates the average percent difference for all laboratories for all samples. These values are shown in Figure 8 along with corresponding numbers from previous studies.

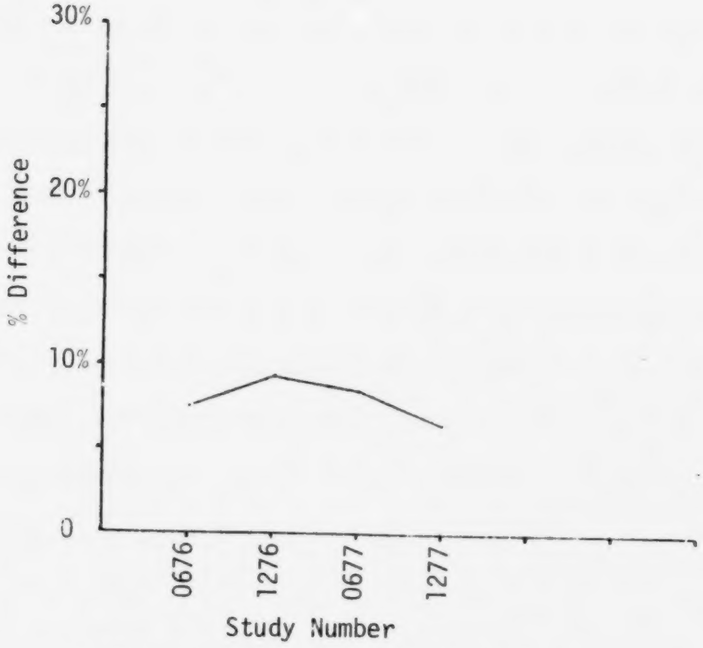


Figure 8. Plot of NO_2 absolute percent differences.

All data received (with exception of the previously omitted data) were grouped according to concentration. The results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 17 and at the top of each listing in the Appendix do not include the data sets identified as outliers.

Table 17 lists summary statistics based on the reported data. The "Outliers Removed" columns contain data on which the outlier criterion was applied. All data that met the second criterion stated in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples.

An examination of Table 17 shows that, with the exception of one sample, all accuracy figures were less than ±5%. All concentrations were normally distributed. Two sets of duplicate samples were analyzed (audits 0677 and 1277). The results showed that the reproducibility was excellent.

Each laboratory data set was plotted against the corresponding EPA data set, and the slope and intercept of the linear regression were determined. For audit 1276, the mean of 108 slopes was 1.024 with a standard deviation of 0.081. The mean intercept was 0.003 with a standard deviation of 0.026. Audit 0677 had a mean slope of 0.970 with a standard deviation of 0.095. The mean intercept was 0.000 with a standard deviation of 0.025. Audit 1277 had a slope of 0.969 with a standard deviation of 0.153. The intercept was -0.001 with a standard deviation of 0.068. Figure 9 shows a tally of these results.

TABLE 17. NO_2 SURVEY STATISTICS (μg/ml)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed
					NO_2 Audit - 1276					
Number	106	104	105	103	108	106	108	107	107	105
True value	0.12	0.12	0.18	0.18	0.33	0.33	0.54	0.54	0.87	0.87
Mean	0.12	0.12	0.17	0.17	0.32	0.32	0.52	0.51	0.85	0.85
Median	0.12	0.12	0.17	0.17	0.32	0.32	0.52	0.52	0.86	0.86
Range	0.17	0.14	0.24	0.15	0.20	0.18	0.36	0.20	0.54	0.31
Std. Dev.	0.03	0.02	0.03	0.02	0.03	0.03	0.05	0.04	0.07	0.06
Coef. Var.	22.52	20.40	16.48	13.49	10.37	9.47	9.40	8.34	7.94	6.66
Skewness[1]	0.17	-0.57	-0.73	0.04	0.07	-0.52	0.60	-0.56	0.48	-0.20
Accuracy[2]	0.00	0.00	-3.87	-3.87	-0.61	-1.07	-2.99	-2.99	-1.61	-1.61
					NO_2 Audit - 0677					
Number	88	86	91	89	86	85	93	90	90	88
True value	0.12	0.12	0.24	0.24	0.24	0.24	0.38	0.38	0.69	0.69
Mean	0.13	0.13	0.25	0.25	0.25	0.25	0.39	0.39	0.72	0.71
Median	0.13	0.13	0.25	0.25	0.25	0.25	0.39	0.39	0.71	0.71
Range	0.15	0.10	0.30	0.12	0.26	0.13	0.54	0.17	0.71	0.24
Std. Dev.	0.02	0.02	0.03	0.02	0.03	0.02	0.06	0.03	0.07	0.04
Coef. Var.	15.86	12.43	12.14	8.04	11.95	9.22	14.30	7.37	9.64	5.38
Skewness[1]	-1.29	0.37	1.69	-0.71	2.05	-0.64	1.14	-0.17	3.72	-0.46
Accuracy[2]	8.40	8.40	4.62	4.62	2.46	2.45	2.38	2.38	2.82	2.82
					NO_2 Audit - 1277					
Number	84	81	86	83	87	85	86	85	88	87
True value	0.18	0.18	0.31	0.31	0.50	0.50	0.50	0.50	0.87	0.87
Mean	0.19	0.19	0.33	0.33	0.52	0.52	0.52	0.52	0.88	0.89
Median	0.19	0.19	0.32	0.32	0.52	0.52	0.52	0.52	0.89	0.89
Range	0.19	0.13	0.18	0.13	0.19	0.14	0.19	0.15	0.96	0.29
Std. Dev.	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.10	0.04
Coef. Var.	13.73	10.53	8.05	6.52	5.42	4.47	5.51	4.91	11.51	4.99
Skewness[1]	-0.31	0.28	0.15	0.21	-0.97	0.14	-0.70	0.08	-6.63	-0.85
Accuracy[2]	2.49	2.21	4.18	4.18	4.44	4.44	3.17	3.17	2.30	2.30

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a Normal distribution this value is near zero.

[2] Accuracy - $\frac{\text{Median - True value}}{\text{True value}} \times 100$

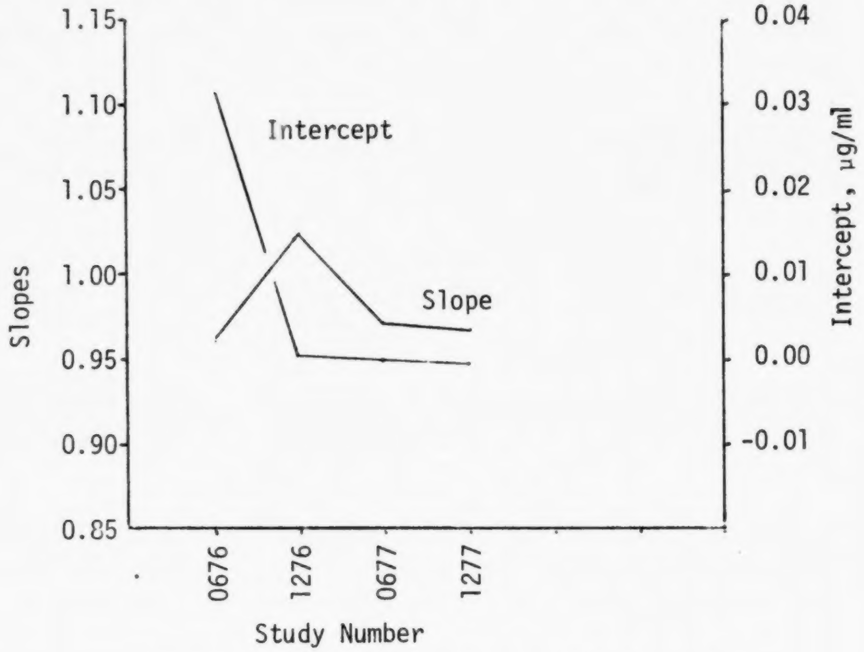


Figure 9. Plot of NO_2 slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the laboratories whose data were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). The following table (Table 18) resulted.

As can be seen, no particular analytical method was responsible for an unusually large portion of the outlier data.

TABLE 18. SUMMARY OF NO_2 ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total Number Using Method	Number Identified as Outliers	Percent of Total as Outliers
	NO_2 Audit - 1276		
Sodium Arsenite - Man.	72	1	1%
Sodium Arsenite - Auto.	28	1	4%
	NO_2 Audit - 0677		
Sodium Arsenite - Man.	62	2	3%
	NO_2 Audit - 1277		
Sodium Arsenite - Man.	56	2	4%
Sodium Arsenite - Auto.	24	1	4%

To determine whether a particular analytical method produced biased results, Table 19 was developed. This table contains the mean and standard deviation of each sample concentration for each method used. As can be seen, the automated sodium arsenite method is the most precise of all the methods. This procedure also appears to yield the most accurate results. However, with the exception of the "Other" category, the remainder of the methods also estimate the EPA value quite adequately.

Recheck Program

Starting with audit 1276, a recheck program was begun. Any laboratory reporting at least three results that were greater than ±20% of the EPA values was sent a second set of samples. This procedure would distinguish between labs having chronic problems and those that had a "bad day." For audit 1276, six laboratories received a second set. Of the six groups returning data, four had corrected their problem to the extent that at least three samples fell within ±20% of the EPA values.

Seven laboratories received recheck samples for audit 0677. Five of these groups returned data, of which all had corrected their problems. Three

TABLE 19. MEAN AND STANDARD DEVIATION OF NO_2 RESULTS BY ANALYTICAL METHOD (μg/ml)

Method	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
NO_2 Audit - 1276										
Saltzman - Man.	0.11	0.02	0.16	0.03	0.34	0.01	0.49	0.04	0.81	0.05
Sodium Arsenite-Man.	0.12	0.03	0.17	0.04	0.32	0.04	0.51	0.06	0.85	0.08
Sodium Arsenite-Auto.	0.12	0.02	0.16	0.05	0.32	0.02	0.52	0.03	0.86	0.04
TGS - ANSA-Man.	0.14	0.06	0.21	0.04	0.35	0.05	0.54	0.04	0.89	0.04
Other	0.12	0.01	0.17	0.01	0.31	0.01	0.54	0.01	0.86	0.01
True value	0.12		0.18		0.33		0.54		0.87	
NO_2 Audit - 0677										
Saltzman-Man.	0.13	0.00	0.25	0.00	0.25	0.00	0.38	0.00	0.68	0.02
Sodium Arsenite-Man.	0.12	0.02	0.25	0.04	0.25	0.04	0.39	0.06	0.73	0.08
Sodium Arsenite-Auto.	0.13	0.01	0.24	0.02	0.24	0.02	0.38	0.03	0.70	0.06
TGS - ANSA-Man.	0.15	0.02	0.26	0.02	0.25	0.02	0.52	0.19	0.69	0.01
Other	0.12	0.02	0.26	0.02	0.26	0.01	0.40	0.04	0.72	0.02
True value	0.12		0.24		0.24		0.38		0.69	
NO_2 Audit - 1277										
Saltzman-Man.	0.19	0.02	0.33	0.02	0.52	0.04	0.52	0.02	0.87	0.04
Sodium Arsenite-Man.	0.19	0.03	0.32	0.03	0.52	0.03	0.52	0.03	0.89	0.05
Sodium Arsenite-Auto.	0.18	0.01	0.32	0.01	0.52	0.02	0.52	0.02	0.84	0.18
TGS - ANSA-Man.	0.20	0.00	0.32	0.02	0.52	0.01	0.52	0.00	0.89	0.02
Other	0.22	0.03	0.34	0.02	0.53	0.03	0.53	0.03	0.91	0.04
True value	0.18		0.31		0.52		0.50		0.87	

agencies received recheck samples for audit 1277. The one that returned data had corrected its problem.

Only one agency receiving recheck samples did so in at least two of the above audits. Thus, it appears that only a few agencies performing NO_2 analysis still have basic analytical problems. It also appears that most of the problems uncovered during the initial analysis were corrected before the recheck samples were received.

Summary

The NO_2 audit start dates ranged from December 1976 through December 1977. The number of participants varied from 123 to 130. Foreign, EPA, State, local, and private laboratories submitted results.

Four analytical methods were used. The majority of the laboratories in all audits used the manual sodium arsenite procedure. Approximately 25% of the laboratories used the automated sodium arsenite procedure.

The overall results showed no bias of any practical significance between the reported and EPA values. The data from each audit appeared to be Normally distributed.

The automated sodium arsenite provided the most accurate and precise results.

The average slopes (Reported vs. EPA) for each audit ranged from 0.97 to 1.04. The intercepts varied from -0.001 to 0.003 μg/ml.

AMBIENT CARBON MONOXIDE

Participant Characteristics

Carbon monoxide audit number 1076 began in October 1976. Out of 119 agencies requesting samples, 92 returned data for a response rate of 77%. Two hundred forty-seven instruments were tested. Audit number 0377 began in March 1977. Out of 142 agencies requesting samples, 116 returned data for a response rate of 82%. A total of 295 CO monitors were audited. Audit number 0977 began in September 1977. Out of 142 agencies requesting samples, 104 responded with data for a return rate of 73%. The number of instruments audited totaled 257.

Table 20 indicates the monitoring agency type distribution.

TABLE 20. CO AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
			CO Audit - 1076			
Agencies Requesting Samples	1	7	43	63	4	119
Agencies Returning Data	1	4	34	51	2	92
			CO Audit - 0377			
Agencies Requesting Samples	2	6	48	77	9	142
Agencies Returning Data	2	2	45	64	3	116
			CO Audit - 0977			
Agencies Requesting Samples	2	6	51	74	9	142
Agencies Returning Data	1	3	42	55	3	104

Methods used to analyze the samples were grouped into three categories. Table 21 lists the analytical methods used and the number of instruments using the method.

TABLE 21. CO ANALYTICAL METHODS

Method	Number Analyzers Using Method		
	Audit 1076	Audit 0377	Audit 0977
NDIR	187	243	219
FID	51	42	31
Other	9	10	7

Most of the instruments classified as "Other" use an electrochemical method of detection.

Agencies generally employ a liberal interpretation of the analytical method used. However, in the case of CO analyses, the methods are clearly defined. Unknowns that could effect results and are considered part of the analytical system are purity of zero air and accuracy of calibration standards.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample Ranges and Target Ranges for the audits are listed in Table 22. The ranges apply to sample concentrations in ascending order.

TABLE 22. CO SAMPLE AND TARGET RANGES

	Concentration 1	Concentration 2	Concentration 3
		CO Audit - 1076	
Sample Range	± 11.1%	± 2.4%	± 1.2%
Target Range	± 11.1%	± 10%	± 10%
		CO Audit - 0377	
Sample Range	± 12.9%	± 2.7%	± 1.4%
Target Range	± 12.9%	± 10%	± 10%
		CO Audit - 0977	
Sample Range	± 10.4%	± 3.0%	± 1.4%
Target Range	± 10.4%	± 10%	± 10%

The Sample Ranges were not determined by the method described under Statistical Approach. Because filling of the cylinders was done so precisely, the standard deviations of the verification analyses were small.

Thus, using the method described under Statistical Approach resulted in unreasonably small Sample Ranges for all concentrations. Rather than use unrealistic values, the Sample Ranges were set at the QAB determined value ±0.5 ppm.

The Target Ranges were determined from previous CO audit results. Earlier studies indicated that the average percent difference between reported results and EPA determined values for all sample concentrations was ±10%. Thus, this value has been used for all Target Ranges with the exception of Concentration 1. In that case, the Sample Range was used because of its larger value.

Using the above criteria, a tabulation was made of the number of instruments reporting results within the ranges. For audit 1076, a total of 103 instruments (42%) reported all values within the Target Ranges, while 16 instruments (6%) reported all results outside the Target Ranges. The corresponding values for audit 0377 showed 153 (52%) and 16 (5%), respectively. Audit 0977 showed 119 (46%) and 9 (4%), respectively. These results compare with previous audits in that 46% of the instruments in audit 0476 reported all values within the Target Ranges, while 9% reported all values outside the Target Ranges. Figure 10 shows a running graphical plot of the above values.

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that any instrument not reporting at least one value within the Target Ranges would be considered an outlier. The Target Ranges are broad enough that, unless an instrument is totally out of control, at

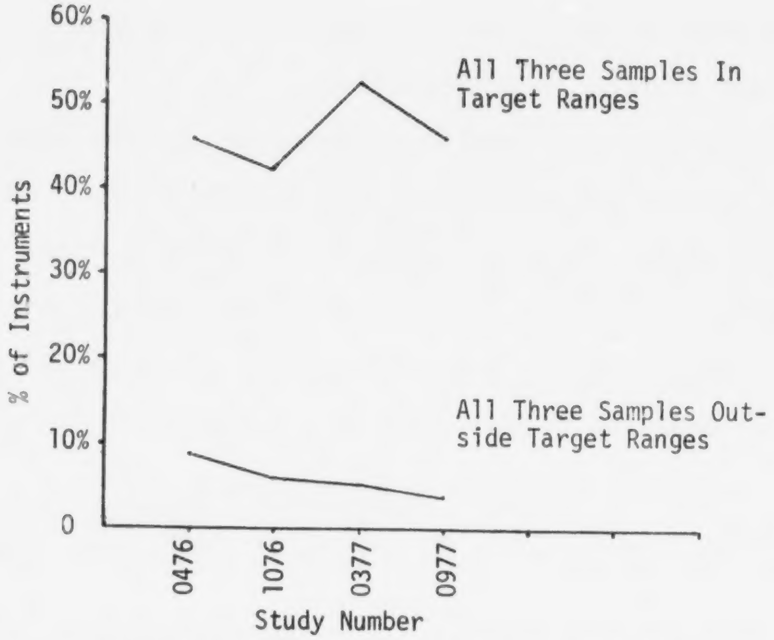


Figure 10. Plot of CO results (three samples within and outside Target Ranges).

least one value would fall within the ranges. This should occur if the instrument is performing similarly to most of the study population. If the instrument is not performing in a similar manner, its data should not be included in the summaries. The remainder of the discussion will deal with the reported results minus the values identified as outliers. These results are eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

Table 23 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{Absolute Percent Difference} = \left|\frac{\text{Reported value} - \text{EPA value}}{\text{EPA value}}\right| \times 100 \cdot$$

The frequency distribution was then constructed and appears below. It should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

Table 23 is very useful for laboratories trying to determine their performance relative to the other participants. For example, in audit 1076 only 10% of the instruments reporting results for Concentration 1 had a percent difference of 0.2% or less, while 50% of the instruments reported a difference of 9.1% or less for the same concentration. The table also indicates the average percent difference for all instruments for all samples.

TABLE 23. ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
CO Audit - 1076									
Concentration 1	228	0.2	0.2	4.2	9.1	11.5	22.4	842.1	19.2
Concentration 2	230	0.1	0.7	1.7	3.1	5.5	10.3	89.4	5.3
Concentration 3	214	0.1	0.4	1.4	2.2	4.1	7.1	32.5	3.6
All Samples	672	0.1	0.4	1.8	3.9	7.1	15.7	842.1	9.5
CO Audit - 0377									
Concentration 1	279	0.6	3.6	6.5	11.2	18.3	33.1	85.2	15.1
Concentration 2	278	0.1	0.8	2.3	4.0	5.9	11.8	101.6	5.7
Concentration 3	275	0.1	0.6	1.5	2.5	4.2	8.8	52.7	4.4
All Samples	832	0.1	0.8	2.5	4.2	9.0	21.0	101.6	8.4
CO Audit - 0977									
Concentration 1	243	0.2	1.9	6.0	8.1	14.4	23.8	202.7	12.4
Concentration 2	244	0.1	0.5	1.9	3.6	5.5	10.1	29.5	4.6
Concentration 3	244	0.0	0.3	1.2	2.0	3.9	8.3	22.2	3.4
All Samples	731	0.0	0.5	1.9	4.3	7.3	15.7	202.7	6.8

These values are tabulated in Figure 11 along with corresponding values from previous audits.

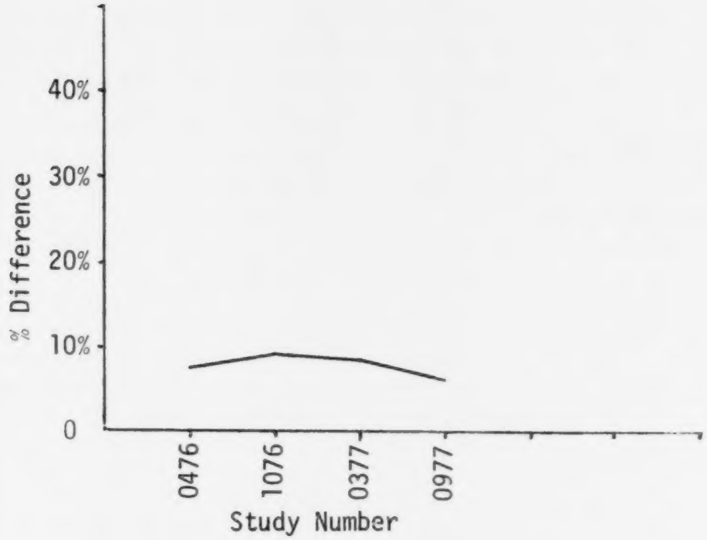


Figure 11. Plot of CO absolute percent differences.

All data received (with the exception of the previously omitted data) were grouped according to concentration. The results for each sample value are listed in the Appendix, in increasing concentration. The summary statistics which appear in Table 24 and at the top of each listing in the Appendix do not include the data sets identified as outliers.

TABLE 24. CO SURVEY STATISTICS (ppm)

	Concentration 1		Concentration 2		Concentration 3	
	All Data	Outliers Removed	All Data	Outliers Removed	All Data	Outliers Removed
			CO Audit - 1076			
Number	228	225	230	227	214	210
True value	4.5	4.5	20.9	20.9	40.1	40.1
Mean	4.6	4.2	21.2	21.1	40.7	40.7
Median	4.3	4.3	21.0	21.0	40.4	40.4
Range	40.9	4.4	23.7	10.8	16.4	9.6
Std. Dev.	3.7	0.6	2.0	1.3	2.1	1.7
Coef. Var.	70.7	14.2	9.3	6.3	5.1	4.2
Skewness[1]	9.0	-0.7	4.2	-0.1	1.8	0.7
Accuracy[2]	-4.7	-5.5	0.7	0.7	0.8	0.6
			CO Audit - 0377			
Number	279	276	278	275	275	268
True value	3.4	3.4	15.9	15.9	31.7	31.7
Mean	3.1	3.1	16.2	15.1	32.5	32.3
Median	3.0	3.0	16.0	16.0	32.2	32.1
Range	4.5	3.3	20.0	8.3	29.5	10.2
Std. Dev.	0.6	0.6	1.5	1.1	2.3	1.5
Coef. Var.	19.4	18.1	9.3	6.8	7.0	4.6
Skewness[1]	-0.2	-0.2	4.4	0.2	0.1	1.0
Accuracy[2]	-10.1	-10.1	0.8	0.8	1.5	1.2
			CO Audit - 0977			
Number	243	242	244	242	244	239
True value	4.8	4.8	16.6	16.6	36.0	36.0
Mean	4.6	4.6	16.7	16.7	36.7	36.6
Median	4.5	4.5	16.7	16.7	36.4	36.4
Range	12.0	4.8	9.3	6.0	13.2	9.4
Std. Dev.	0.9	0.7	1.0	1.0	1.7	1.4
Coef. Var.	20.2	15.2	6.2	5.8	4.7	3.9
Skewness[1]	4.9	0.4	-0.2	-0.0	1.1	0.4
Accuracy[2]	-6.0	-6.0	0.6	0.6	1.1	1.1

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a Normal distribution this value is near zero.

[2] Accuracy - $\frac{\text{Median - True value}}{\text{True value}} \times 100$

Table 24 lists summary statistics based on the reported data. The "Outliers Removed" column contains data on which the outlier criterion was applied. All data that met the second criterion in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples.

An examination of the data in Table 24 reveals no bias or skewness problems in any of the audits. The greatest inaccuracy was -6.7%. The near zero value of the skewness indicator shows that the distribution was normal.

The EPA determined "True value" and the median of the study results agree well. This is indicated by the "Accuracy" values. The study population is normally distributed as indicated by the "Skewness".

Each instrument data set was plotted against the corresponding EPA data set, and the slope and intercept from the linear regression were determined. For audit 1076, the mean of 230 slopes was 0.963 with a standard deviation of 0.125. The mean intercept was 0.642 with a standard deviation of 3.062. Audit 0377 had a mean slope of 0.963 with a standard deviation of 0.067. The mean intercept was 0.423 with a standard deviation of 0.926. A total of 278 instrument results were used to determine these values. Audit 0977 had a slope of 0.973 with a standard deviation of 0.055. The intercept was 0.324 with a standard deviation of 1.012. The number of instrument results used to calculate these values was 248. Figure 12 shows a tally of these results.

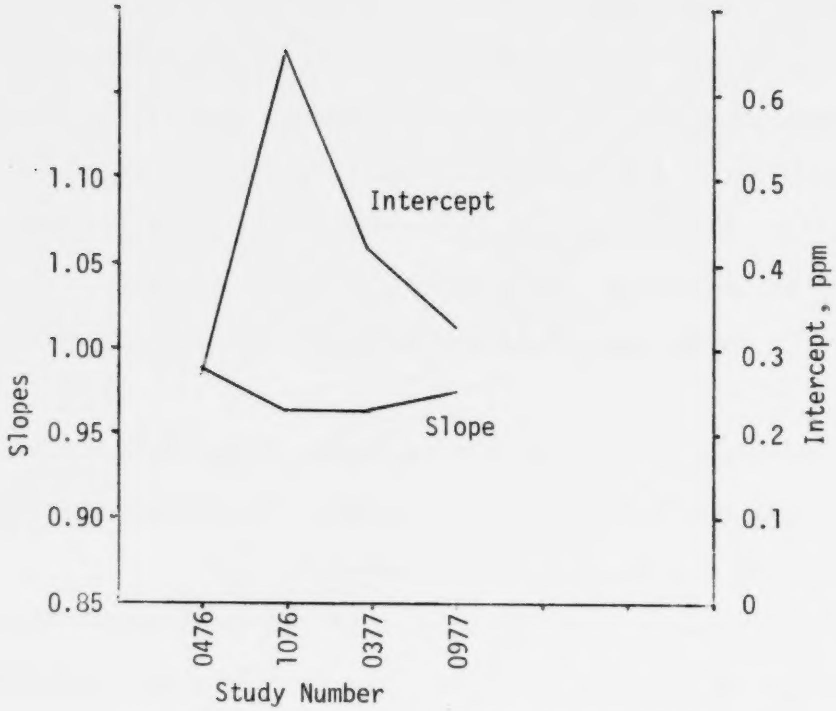


Figure 12. Plot of CO slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the instruments whose data were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). The following table (Table 25) resulted. As can be seen, both of the predominately used methods contributed approximately equally to the outlier data.

TABLE 25. SUMMARY OF CO ANALYTICAL METHODS USED BY OUTLIER INSTRUMENTS

Method	Total No. Using Method	No. Identified as Outliers	% of Total as Outliers
		CO Audit - 1076	
NDIR	187	11	6%
Flame Ionization	51	5	10%
Other	9	-	0%
		CO Audit - 0377	
NDIR	243	15	6%
Flame Ionization	42	1	2%
Other	10	-	0%
		CO Audit - 0977	
NDIR	219	6	3%
Flame Ionization	31	3	10%
Other	7	--	0%

To determine whether a particular analytical method produced results that contained a bias, Table 26 was developed. This table contains the mean and standard deviation of each sample concentration for each method used.

TABLE 26. MEAN AND STANDARD DEVIATION OF CO RESULTS BY ANALYTICAL METHOD (ppm)

Method	Concentration 1		Concentration 2		Concentration 3	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
			CO Audit - 1076			
NDIR	4.8	4.2	21.3	1.9	40.6	1.6
Flame Ionization	4.0	0.9	20.8	2.2	41.2	3.3
Other	4.4	0.5	20.9	0.7	39.4	0.8
True value	4.5		20.9		40.1	
			CO Audit - 0377			
NDIR	3.1	0.6	16.2	1.0	32.4	1.5
Flame Ionization	2.9	0.3	16.5	3.2	32.7	4.6
Other	3.5	0.8	15.6	1.0	31.6	1.5
True value	3.4		15.9		31.7	
			CO Audit - 0977			
NDIR	4.6	1.0	16.5	2.5	36.5	3.1
Flame Ionization	4.0	0.5	15.9	1.4	36.5	1.7
Other	5.0	0.8	17.2	0.6	36.6	1.9
True value	4.8		16.6		36.0	

The data indicate that the NDIR method was the most accurate of the two major methods. However, the "Other" category was the most accurate. The method that showed the best precision varied from audit to audit. The "Other" category was the most precise of the three methods.

Summary

The CO audit start dates covered in this report ranged from October 1976 to September 1977. Number of participants varied from 92 to 116. Number of instruments checked varied from 247 to 295. Foreign, EPA, State, local, and private laboratories submitted data.

Three analytical methods were used. The majority of the instruments were NDIRs. Approximately 80% of the instruments were of this type.

The overall results showed no bias between the reported and EPA values. The results appeared to be normally distributed .

Of the two most used procedures, the NDIR technique seemed to give the most accurate results. However, the "Other" category was the most accurate and precise.

The average slopes (Reported vs. EPA) for each audit varied from 0.963 to 0.973. The intercepts ranged from 0.324 to 0.642.

HI-VOL SULFATE

Participant Characteristics

Sulfate audit number 1076 began in October 1976. Out of 71 sample sets requested by participants, 56 sets of data were returned for a response rate of 79%. Audit number 0277 began in February 1977. Out of 71 sample sets requested, 57 sets of data were returned for a response rate of 80%. Audit number 0877 began in August 1977. Out of 85 sample sets requested, 57 were returned for a response rate of 67%.

Table 27 indicates the monitoring agency type distribution.

TABLE 27. $SO_4^=$ AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
$SO_4^=$ Audit - 1076						
Agencies Requesting Samples	1	5	32	23	10	71
Agencies Returning Data	0	2	27	19	8	56
$SO_4^=$ Audit - 0277						
Agencies Requesting Samples	2	3	30	24	12	71
Agencies Returning Data	2	2	27	18	8	57
$SO_4^=$ Audit - 0877						
Agencies Requesting Samples	3	4	31	30	17	85
Agencies Returning Data	2	3	23	21	8	57

Methods used to analyze the samples were grouped into nine broad categories. Results were received from laboratories using eight methods and are listed in Table 28.

TABLE 28. $SO_4^=$ ANALYTICAL METHODS

Method	Number Agencies Using Method		
	Audit 1076	Audit 0277	Audit 0877
Methylthymol blue - Man.	1	-	-
Methylthymol blue - Auto.	11	13	13
Barium Chloride - Man.	20	18	23
Barium Chloride - Auto.	4	2	2
Sulfa-ver - Man.	17	14	12
Sulfa-ver - Auto.	-	1	1
Barium Chloranilate - Man.	-	1	-
Other	3	8	6

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting the use of the automated methylthymol blue procedure as the method of choice may have used that procedure with various modifications. Thus, Table 28 should be interpreted as meaning that 11 laboratories in audit 1076 used procedures approximating the automated methylthymol blue procedure.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample Ranges and Target Ranges are listed in Table 29. The ranges apply to sample concentrations in ascending order.

TABLE 29. $SO_4^=$ SAMPLE AND TARGET RANGES

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample Range	± 5%	± 5%	± 5%	± 5%	± 5%	± 5%
Target Range	± 15%	± 15%	± 15%	± 15%	± 15%	± 15%

Neither the Sample Ranges nor the Target Ranges were determined using the methods described under Statistical Approach. Both ranges were arbitrarily set at the values listed in Table 29. As more audits are conducted and more data become available, the ranges will be refined.

Using the above criteria, a tabulation was made of the number of agencies reporting results within the ranges. For audit 1076, five (9%) agencies reported five or six results within the Target Ranges, while seven (12%) laboratories reported all results outside these ranges. The corresponding figures for audit 0277 showed 18 (32%) and 2 (4%), respectively. Audit 0877 showed 15 (26%) and 7 (12%), respectively. The improvement in performance from the first to the second and third studies is probably due to the sample concentrations being analyzed. During audit 1076, most of the samples were near the minimum detectable limit of the methods in use.

The above results compare with previous audits in that 37% of the laboratories reported five or six values within the ranges during audit 0476, and 15% were not able to report any values within the ranges. Figure 13 shows a running graphical plot of the above values.

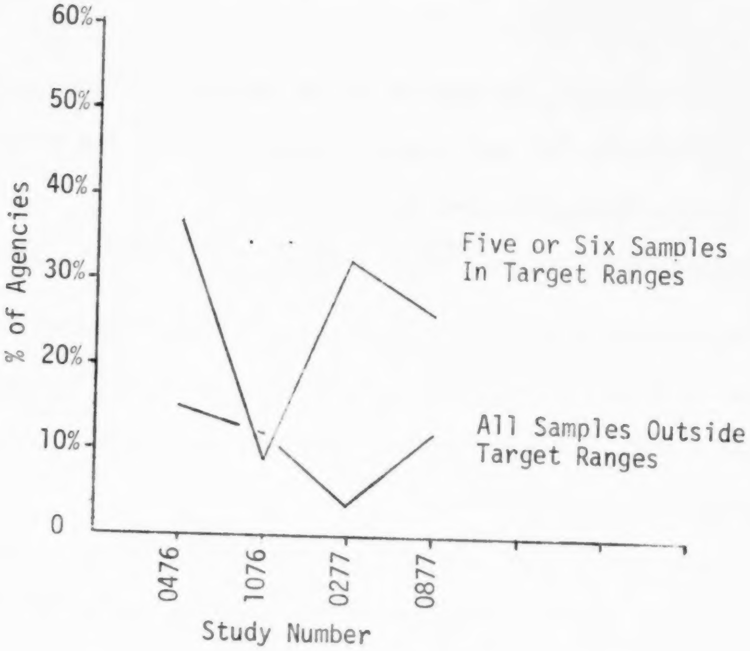


Figure 13. Plot of $SO_4^=$ results (five or six samples within Target Ranges and six samples outside Target Ranges).

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that any laboratory not reporting at least one value within the Target Ranges would be considered an outlier. The Target Ranges are sufficiently broad that, unless a laboratory is totally out of control, at least one value would fall within the ranges; this should occur if the laboratory is performing similarly to most of the study population. If the lab is not performing in a similar manner, its data should not be included in the summaries. Seven laboratories met this criterion for outlier rejection in 1076, two in 0277, and seven in 0877, and were eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

Table 30 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{Absolute Percent Difference} = \left|\frac{\text{Reported value - EPA value}}{\text{EPA value}}\right| \times 100 .$$

The frequency distribution was then constructed and appears below. It should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

Table 30 is very useful for laboratories trying to determine their performance relative to other participants. For example, only 10% of the labs in Audit 0277 reporting results for Concentration 2 had a percent difference of 1.7% or less, while 50% of the laboratories reported a percent difference of 6.6% or less for the same concentration. The table also indicates the average percent difference for all laboratories for all samples (except Concentration 1). These values are tabulated in Figure 14 along with corresponding values from previous audits.

Concentration 1 was a blank for Audits 1076 and 0877 and was not included in the "All Samples" distribution. Because small concentration differences result in large percent differences, it was felt that the numbers would unduly distort the study results.

TABLE 30. $SO_4^=$ ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
					$SO_4^=$ Audit - 1076				
Concentration 1					Blank				
Concentration 2	48	0.2	6.0	26.4	47.2	92.6	205.8	546.0	83.9
Concentration 3	48	0.4	0.4	5.6	14.5	31.1	66.0	133.1	28.8
Concentration 4	99	0.1	1.2	3.9	7.5	11.3	23.3	82.4	10.3
All Samples	241	0.1	1.9	6.6	14.5	38.0	97.0	546.0	42.7
					$SO_4^=$ Audit - 0277				
Concentration 1	53	0.7	2.2	6.0	12.8	25.7	77.2	838.7	53.7
Concentration 2	107	0.1	1.7	3.8	6.6	10.6	24.3	234.4	14.5
Concentration 3	111	0.0	0.8	3.5	6.3	8.8	20.2	241.2	10.4
Concentration 4	56	0.5	0.9	2.3	4.0	6.7	22.5	48.4	8.8
All Samples	327	0.0	1.3	3.6	6.3	11.0	28.7	838.7	18.5
					$SO_4^=$ Audit - 0877				
Concentration 1					Blank				
Concentration 2	48	2.9	4.8	10.0	19.0	38.1	98.1	205.2	39.2
Concentration 3	50	0.0	1.3	7.0	10.7	33.3	73.7	120.0	26.7
Concentration 4	51	0.0	0.8	2.8	7.0	10.8	18.9	75.7	10.4
Concentration 5	51	0.0	0.9	3.0	6.7	11.1	18.4	1260.0	34.8
Concentration 6	50	0.0	1.6	4.8	6.7	8.8	16.7	72.2	10.2
All Samples	250	0.0	1.4	5.4	9.0	14.3	50.5	1260.0	24.1

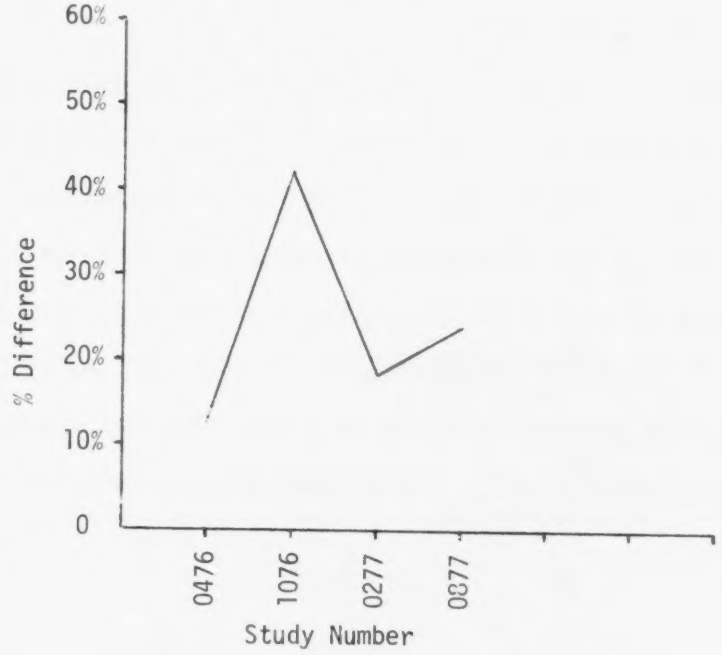


Figure 14. Plot of $SO_4^=$ absolute percent differences.

All data received (with the exception of the previously omitted data) were grouped according to concentration. Results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 31 and at the top of each listing in the Appendix do not include the data sets identified as outliers.

Table 31 lists summary statistics based on reported data. The "Outliers Removed" column contains data on which an outlier test has been applied. All data that met the second criterion in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

An examination of Table 31 shows that all the data are normally distributed. Inaccuracy at some of the concentrations is larger than would be desired. However, most of the inaccuracies occur at low concentrations. Generally, there tends to be a positive bias in the lower concentrations and a negative bias in the higher concentrations.

Each laboratory data set was plotted against the corresponding EPA data set, and the slope and intercept of the linear regression line were determined. For Audit 1076, the mean of 50 slopes was 1.050 with a standard deviation of 0.256. The mean intercept was -0.558 with a standard deviation of 2.262. Audit 0277 had a mean slope of 0.934 with a standard deviation of 0.306. The mean intercept was 1.411 with a standard deviation of 5.538. Audit 0877 had a slope of 1.036 with a standard deviation of 0.196. The intercept was -0.263 with a standard deviation of 1.770. Figure 15 shows a plot of these results.

TABLE 31. $SO_4^=$ SUMMARY STATISTICS ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	a[3]	b[4]	a	b	a	b	a	b	a	b	a	b
$SO_4^=$ Audit - 1076												
Number	39	38	94	92	48	46	99	96				
True value	0.00	0.00	1.22	1.22	3.01	3.01	10.2	10.2				
Mean	1.24	1.12	1.96	1.84	3.26	3.10	10.2	10.1				
Median	0.90	0.85	1.65	1.59	3.10	3.10	10.1	10.1				
Range	5.76	3.64	7.81	5.38	6.93	6.21	14.0	6.6				
Std. Dev.	1.26	1.02	1.43	1.17	1.32	1.09	1.6	1.2				
Coef. Var.	101.2	91.1	72.8	63.0	40.6	35.3	15.9	11.5				
Skewness[1]	1.51	0.89	1.8	1.2	0.8	0.3	-0.5	0.5				
Accuracy[2]	-	-	34.9	30.0	3.1	2.9	-1.2	-1.2				
$SO_4^=$ Audit - 0277												
Number	53	51	107	105	111	110	56	54				
True value	4.5	4.5	15.6	15.6	21.2	21.2	24.9	24.9				
Mean	6.1	5.1	16.2	15.5	21.3	20.9	24.2	24.2				
Median	4.6	4.6	15.9	15.9	21.1	21.0	24.4	24.4				
Range	41.6	20.6	51.1	23.4	58.2	13.0	23.2	17.3				
Std. Dev.	6.4	2.8	5.6	2.7	5.4	2.4	3.6	2.9				
Coef. Var.	104.1	56.1	34.5	17.1	25.4	11.5	14.8	11.9				
Skewness	4.1	3.6	4.5	-1.8	7.3	-0.5	-0.4	-0.8				
Accuracy	3.4	2.9	1.7	1.7	-0.3	-0.5	-1.8	-1.8				
$SO_4^=$ Audit - 0877												
Number	34	33	48	46	50	49	51	49	51	50	50	48
True value	0.0	0.0	2.1	2.1	3.0	3.0	11.1	11.1	13.5	13.5	16.2	16.2
Mean	1.0	0.9	2.5	2.4	3.2	3.1	10.9	10.8	16.5	13.2	16.1	15.7
Median	0.6	0.6	2.4	2.3	3.0	3.0	10.8	10.8	13.3	13.3	15.4	15.4
Range	5.0	3.0	6.4	5.0	6.1	5.5	13.7	6.8	181.0	18.7	15.9	9.0
Std. Dev.	1.1	0.8	1.2	1.0	1.2	1.1	1.8	1.2	24.0	2.3	2.7	1.6
Coef. Var.	107.5	93.9	47.9	40.5	37.9	35.7	16.8	11.0	145.4	17.8	16.6	10.0
Skewness	1.8	1.2	1.1	0.5	0.5	0.2	1.7	0.5	6.6	-1.0	2.5	0.6
Accuracy	-	-	11.9	9.5	1.5	1.0	-2.7	-2.7	-1.3	-1.3	-5.0	-5.2

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a Normal distribution this value is near zero.

[2] Accuracy - $\frac{\text{Median - True value}}{\text{True value}} \times 100$

[3] All Data

[4] Outliers Removed

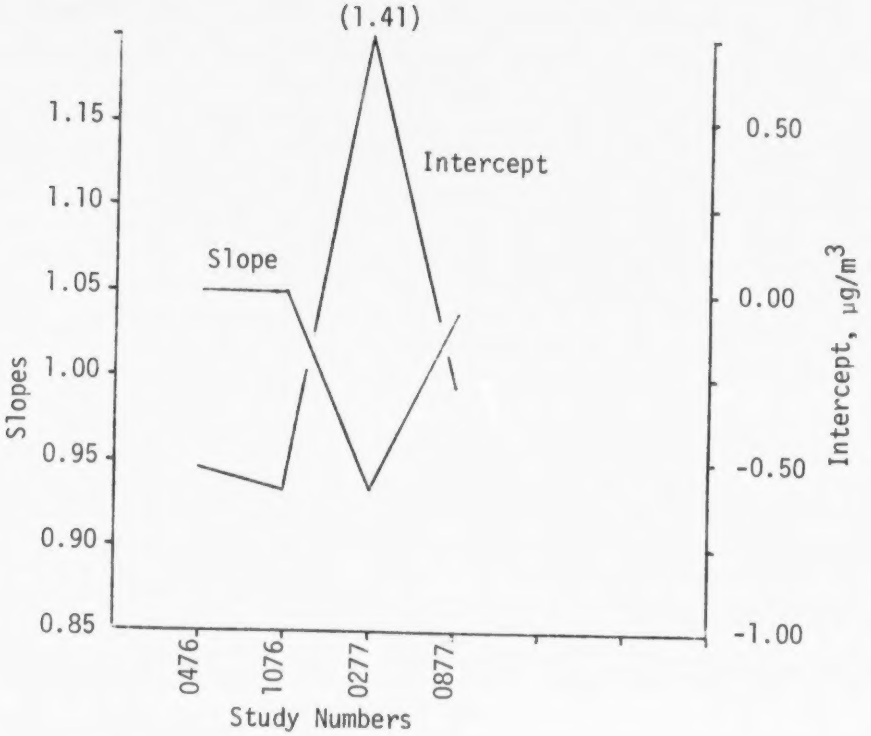


Figure 15. Plot of $SO_4^=$ slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the laboratories that submitted data that were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). Table 32 resulted from this check.

TABLE 32. SUMMARY OF $SO_4^=$ ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total No. Using Method	No. Identified as Outliers	% of Total as Outliers
	$SO_4^=$ Audit - 1076		
Methylthymol blue-Auto.	11	1	9%
Barium Chloride-Man.	20	3	15%
Sulfa-ver-Man.	17	2	12%
Other	3	1	33%
	$SO_4^=$ Audit - 0277		
Sulfa-ver-Man.	14	2	14%
	$SO_4^=$ Audit - 0877		
Barium Chloride-Man.	23	1	4%
Sulfa-ver-Man.	12	2	17%
Sulfa-ver-Auto.	1	1	100%
Other	6	3	50%

While none of the methods are responsible for a large percentage of the outlier data, the manual barium chloride and manual Sulfa-ver methods are responsible for outlier data in at least two of the three audits.

To determine whether a particular analytical method produced biased results, Table 33 was developed. This table contains the means and standard deviations of each sample concentration for each method used.

In general, the automated methythymol blue procedure was the most accurate and precise. There was little difference in the accuracies of both barium chloride methods and the manual Sulfa-ver method. The automated barium chloride was more precise than the manual barium chloride. None of the methods showed a large bias.

Summary

The SO_4 audit start dates covered in this report ranged from October 1976 to August 1977. The number of participants remained constant at 57.

TABLE 33. MEAN AND STANDARD DEVIATION OF $SO_4^=$ RESULTS BY ANALYTICAL METHOD ($\mu g/m^3$)

Method	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
$SO_4^=$ Audit - 1076												
MTB - Man.	5.80	-	4.27	0.72	5.80	-	10.76	0.38				
MTB - Auto.	0.84	1.17	1.35	0.54	3.38	1.07	10.46	1.04				
BaCl - Man.	0.95	0.98	2.35	1.82	3.27	0.88	10.24	2.22				
BaCl - Auto.	1.10	1.30	1.93	1.29	3.55	2.38	10.96	1.42				
Sulfa-ver -Man.	1.09	1.02	1.43	1.04	3.12	1.51	9.77	0.90				
Other	0.10	0.13	2.70	2.14	1.79	0.50	8.66	1.32				
True value	0.00		1.22		3.01		10.22					
$SO_4^=$ Audit - 0277												
MTB - Auto.	4.47	0.78	16.28	1.04	20.92	1.94	24.97	1.14				
BaCl - Man.	5.77	5.40	15.14	2.88	22.15	8.74	23.18	3.80				
BaCl - Auto.	3.05	0.07	14.94	1.13	19.37	3.66	24.64	1.93				
Sulfa-ver -Man.	6.45	5.04	14.64	3.67	20.02	2.26	24.24	4.97				
Sulfa-ver -Auto.	4.50	-	17.10	1.27	21.00	8.48	21.90	-				
Ba Chlor.-Man.	10.08	-	18.22	1.02	24.12	0.51	32.10	-				
Other	9.13	13.27	20.75	12.16	22.22	1.92	25.10	2.49				
True value	4.47		15.63		21.16		24.87					
$SO_4^=$ Audit - 0877												
MTB - Auto.	0.36	0.49	1.98	0.66	2.92	0.43	10.51	1.07	12.87	1.07	15.55	1.08
BaCl - Man.	0.91	1.33	2.44	1.57	3.24	1.56	10.93	3.16	20.60	36.64	16.30	4.98
BaCl - Auto.	0.00	0.00	1.02	1.39	1.40	0.86	10.60	0.84	13.31	0.98	15.03	1.46
Sulfa-ver -Man.	0.75	0.97	2.99	1.45	3.29	1.46	10.54	2.56	13.04	2.17	15.34	1.94
Other	0.54	0.57	2.28	0.52	3.04	0.29	10.24	0.73	12.51	0.72	15.44	0.47
True value	0.00		2.10		3.00		11.10		13.50		16.20	

Foreign, EPA, State, local, and private laboratories submitted data.

Eight analytical methods were used. The majority of the laboratories used either the automated methylthymol blue, manual barium chloride, or manual Sulfa-ver methods.

The overall results showed no bias between the reported and EPA values. The statistical distributions appeared to be normal. Audit 1076, which had most of the sample concentrations near the detectable limits of the methods, showed the greatest inaccuracies.

The automated methythymol blue method exhibited the greatest accuracy and precision. The barium chloride and Sulfa-ver methods were approximately equal in accuracy.

The average slopes (Reported vs. EPA) for each audit ranged from 0.931 to 1.05. The intercepts varied from -0.558 to 1.411.

HI-VOL NITRATE

Participant Characteristics

Nitrate audit number 1076 began in October 1976. Out of 56 laboratories returning sulfate data, 41 submitted nitrate results. Audit 0277 began in February 1977. Out of 57 sulfate results received, 47 returned nitrate data. Audit 0877 began in August 1977. Out of 57 laboratories returning sulfate data, 39 of these laboratories also submitted nitrate results.

Table 34 indicates the monitoring agency type distribution.

TABLE 34. NO_3^- AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
NO_3^- Audit - 1076						
Agencies Requesting Samples	1	1	20	12	7	41
Agencies Returning Data	1	1	20	12	7	41
NO_3^- Audit - 0277						
Agencies Requesting Samples	2	3	21	13	8	47
Agencies Returning Data	2	3	21	13	8	47
NO_3^- Audit - 0877						
Agencies Requesting Samples	3	2	16	10	8	39
Agencies Returning Data	3	2	16	10	8	39

Methods used to analyze the samples were grouped into five broad categories. Table 35 lists the analytical methods used and the number of respondents using the method.

TABLE 35. NO_3^- ANALYTICAL METHODS

Method	Number Agencies Using Method		
	Audit 1076	Audit 0277	Audit 0877
Cadmium reduction - Man.	4	6	4
Cadmium reduction - Auto.	15	16	11
Hydrazine reduction - Man.	3	2	1
Hydrazine reduction - Auto.	3	5	7
Other	16	18	16

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting the use of the automated cadmium reduction method as the procedure of choice may have used that method with various modifications. Thus, Table 35 should be interpreted as meaning that 15 laboratories in audit 1076 used procedures approximating the automated cadmium reduction method.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample Ranges and Target Ranges for NO_3 are listed in Table 36. The ranges apply to sample concentrations in ascending order.

TABLE 36. NO_3^- SAMPLE AND TARGET RANGES

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample Range	± 5%	± 5%	± 5%	± 5%	± 5%	± 5%
Target Range	± 15%	± 15%	± 15%	± 15%	± 15%	± 15%

Neither the Sample Ranges nor the Target Ranges were determined using the methods described under Statistical Approach. Both ranges were arbitrarily set at the values listed in Table 36. As more audits are conducted and more data become available, the ranges will be refined.

Using the above criteria, a tabulation was made of the number of agencies reporting results within the ranges. For audit 1076, a total of 10 (24%) agencies reported five or six results within the Target Ranges, while four (10%) laboratories reported all results outside these ranges. The corresponding figures for audit 0277 showed 22 (48%) and 7 (15%), respectively. Audit 0877 showed nine (23%) and four (10%), respectively.

The above results compared with previous audits in that 59% of the laboratories reported five or six values within the ranges during audit 0476, and 17% were not able to report any values within the ranges. Figure 16 shows a graphical plot of the above values.

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that any laboratory not reporting at least one value within the Target Ranges would be considered an outlier. The Target Ranges are sufficiently broad that, unless a laboratory is totally out of control, at least one value would fall within the ranges; this should occur if the laboratory is performing similarly to most of the study population. If the lab is not performing in a similar manner, its data should not be included in the summaries. Four laboratories met this criterion for outlier rejections in audit 1076, seven in 0277, and four in 0877, and were eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

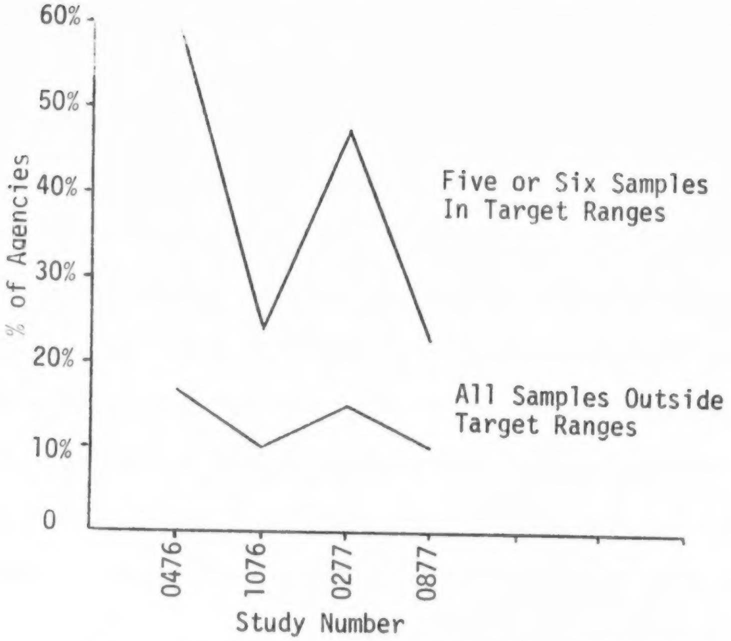


Figure 15. Plot of NO_3^- results (five or six samples within Target Ranges and six samples outside Target Ranges).

Table 37 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{Absolute Percent Difference} = \left| \frac{\text{Reported value - EPA value}}{\text{EPA value}} \right| \times 100 .$$

The frequency distribution was then constructed and appears below. It should be noted that the "All Samples" line is not an average of the numbers appearing above, but is the data examined together regardless of the concentration.

TABLE 37. NO_3^- ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
NO_3^- Audit - 1076									
Concentration 1	BLANK								
Concentration 2	72	1.8	7.3	11.1	27.8	53.7	77.8	203.7	40.2
Concentration 3	74	0.4	1.8	4.8	7.1	24.0	76.1	155.0	26.2
Concentration 4	37	0.4	1.3	3.1	12.1	29.9	78.6	97.9	28.1
All Samples	183	0.4	1.8	6.2	18.4	44.4	77.8	203.7	32.1
NO_3^- Audit - 0277									
Concentration 1	40	0.0	2.1	6.7	13.9	20.6	36.1	99.5	19.1
Concentration 2	76	0.0	0.8	2.5	7.2	11.8	23.0	49.7	10.0
Concentration 3	38	0.1	0.3	3.8	7.7	10.7	20.3	38.2	9.8
Concentration 4	76	0.2	1.1	2.6	5.3	9.9	20.8	46.1	9.4
All Samples	230	0.0	1.3	3.1	7.1	13.2	28.4	99.5	11.4
NO_3^- Audit - 0877									
Concentration 1	BLANK								
Concentration 2	34	0.0	2.8	16.7	26.4	47.1	90.3	266.7	52.3
Concentration 3	34	0.0	0.8	3.8	9.2	17.7	69.2	89.2	21.9
Concentration 4	35	0.0	1.9	3.1	5.0	8.5	45.0	97.9	18.2
Concentration 5	35	0.9	0.3	2.0	4.2	9.8	42.3	90.8	16.5
Concentration 6	35	0.6	0.9	2.2	4.1	8.2	43.1	93.0	16.5
All Samples	173	0.0	1.3	3.3	7.7	22.2	77.8	266.7	25.0

Table 37 is very useful for laboratories trying to determine their performance relative to other participants. For example, only 10% of the labs in Audit 1076 reported results for Concentration 2 that had a percent difference of 7.4% or less, while 50% of the laboratories reported a percent difference of 27.8% or less for the same concentration. The table also indicates the average percent difference for all laboratories for all samples. These values are tabulated in Figure 17 along with corresponding values from previous audits.

Concentration 1 was a blank for Audits 1076 and 0877 and was not included in the "All Samples" distribution. Because small concentration differences result in large percent differences, it was felt that the numbers would unduly distort the study results.

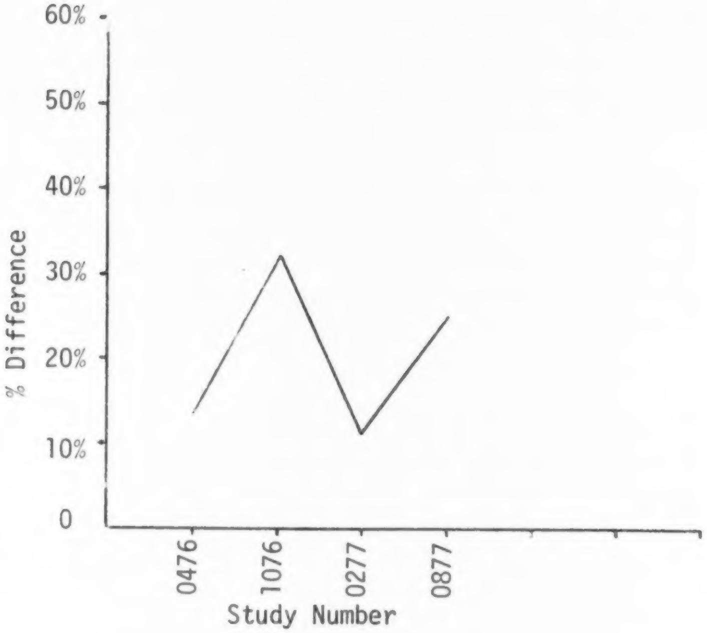


Figure 17. Plot of NO_3^- absolute percent differences.

All data received (with the exception of previously mentioned data) were grouped according to concentration. Results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 38 and at the top of each listing in the Appendix do not include the data sets identified as outliers.

Table 38 lists summary statistics based on reported data. The "Outliers Removed" column contains data on which an outlier test has been applied. All data that met the second criterion described in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

The data in Table 38 indicates that the results are normally distributed (skewness near zero). Certain samples seemed to cause accuracy problems. In general, however, the accuracy was within 5%.

Each laboratory data set was plotted against the corresponding EPA data set, and the slope and intercept of the linear regression line were determined. For Audit 1076 the mean of 37 slopes was 1.393 with a standard deviation of 1.339. The mean intercept was -0.047 with a standard deviation of 1.098. Audit 0277 had a mean slope of 1.076 with a standard deviation of 0.242. The mean intercept was -0.375 with a standard deviation of 1.006. Audit 0877 had a slope of 1.832 with a standard deviation of 0.459. Figure 18 shows a plot of these results.

The mean slopes for audits 1076 and 0877 are much greater than is desired. However, in each case, the slopes were influenced by a few very large laboratory slopes. This can be seen in the standard deviation of the slopes.

TABLE 38. NO_3^- SUMMARY STATISTICS ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	a[3]	b[4]	a	b	a	b	a	b	a	b	a	b
NO_3^- Audit - 1076												
Number	30	30	72	71	74	71	37	37				
True value	0.00	0.00	0.54	0.54	3.4	3.4	9.4	9.4				
Mean	0.23	0.23	0.65	0.64	3.3	3.0	7.2	7.2				
Median	0.26	0.26	0.64	0.64	3.4	3.4	8.4	8.4				
Range	0.46	0.46	1.51	0.97	8.1	4.6	11.5	11.5				
Std. Dev.	0.16	0.16	0.27	0.24	1.5	1.1	3.3	3.3				
Coef. Var.	70.1	70.1	41.1	37.9	46.0	35.3	45.9	45.9				
Skewness[1]	-0.02	-0.02	0.36	-0.31	1.0	-1.1	-0.8	-0.8				
Accuracy[2]	-	-	18.5	18.5	1.8	1.8	-10.8	-10.8				
NO_3^- Audit - 0277												
Number	40	38	76	74	38	37	76	74				
True value	1.94	1.94	5.2	5.2	7.4	7.4	10.9	10.9				
Mean	2.27	1.94	5.3	5.2	7.2	7.3	10.7	10.7				
Median	2.21	2.16	5.3	5.3	7.4	7.4	11.0	11.0				
Range	2.20	1.19	4.0	3.0	4.3	3.8	9.8	6.6				
Std. Dev.	0.43	0.30	0.7	0.6	1.0	0.8	1.6	1.4				
Coef. Var.	19.1	13.6	13.9	12.1	13.2	11.7	14.6	12.7				
Skewness	1.57	0.33	0.4	-0.4	-0.8	-0.5	-0.6	-1.2				
Accuracy	13.9	11.3	2.5	2.2	0.2	0.3	0.7	0.7				
NO_3^- Audit - 0877												
Number	29	28	34	32	34	32	35	33	35	32	35	33
True value	0.00	0.00	0.72	0.72	1.30	1.30	4.80	4.80	6.00	6.00	7.80	7.80
Mean	0.43	0.27	0.96	0.86	1.34	1.41	4.14	4.38	5.43	5.58	6.47	6.92
Median	0.30	0.20	0.86	0.86	1.32	1.33	4.65	4.68	5.82	5.86	7.44	7.48
Range	4.94	1.28	2.57	2.13	2.08	1.94	5.67	5.30	9.75	5.45	7.42	6.15
Std. Dev.	0.91	0.28	0.55	0.39	0.45	0.35	1.49	1.14	1.78	1.07	2.00	1.40
Coef. Var.	212.0	106.0	57.7	45.3	33.8	24.8	35.9	26.1	32.7	19.2	30.5	20.2
Skewness	4.2	1.9	1.4	0.7	-0.9	-0.2	-1.7	-2.0	-1.0	-2.3	-1.8	-2.0
Accuracy	-	-	20.1	19.4	1.9	2.3	-3.1	-2.5	-3.0	-2.2	-4.6	-4.1

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a Normal distribution this value is near zero.

[2] Accuracy - $\dfrac{\text{Median - True value}}{\text{True value}} \times 100$

[3] All Data

[4] Outliers Removed

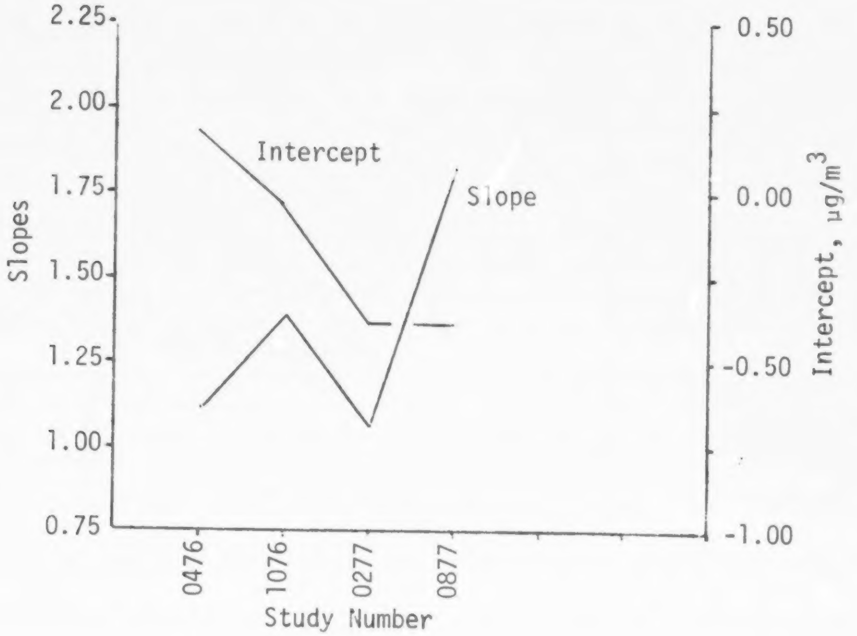


Figure 18. Plot of NO_3^- slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the laboratories that submitted data that was omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). Table 39 resulted from this check.

As can be seen, no one method was responsible for most of the outlier data. An interesting observation that can be made from this table and Table 35 is the number of laboratories using methods classified as "Other". It is obvious that, as yet, no method is the "method of choice".

TABLE 39. SUMMARY OF NO_3^- ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total No. Using Method	No. Identified as Outliers	% of Total as Outliers
		NO_3^- Audit - 1076	
Cad. Reduction-Man.	4	1	25%
Cad. Reduction-Auto.	15	2	13%
Other	16	1	6%
		NO_3^- Audit - 0277	
Cad. Reduction-Man.	6	2	33%
Cad. Reduction-Auto.	16	2	12%
Other	18	3	17%
		NO_3^- Audit - 0877	
Cad. Reduction-Auto.	11	1	9%
Hyd. Reduction-Man.	1	1	100%
Hyd. Reduction-Auto.	7	1	14%
Other	16	1	6%

To determine whether a particular analytical method produced biased results, Table 40 was developed. This table contains the means and standard deviations of each sample concentration for each method used.

The manual hydrazine reduction appears to be the most precise. The automated hydrazine reduction method was more precise than the automated cadmium reduction method, but less precise than the manual hydrazine procedure. The automated hydrazine reduction is also the most accurate, with the automated cadmium reduction next. As pointed out earlier, however, the important point is that most laboratories are not using any of the defined methods.

Summary

The NO_3^- audit start dates covered in this report ranged from October 1976 to August 1977. The number of participants submitting ranged from 39 to 47. Foreign, EPA, State, local, and private laboratories returned results.

TABLE 40. MEAN AND STANDARD DEVIATION OF NO_3^- RESULTS BY ANALYTICAL METHOD

Method	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
NO_3^- Audit - 1076												
Cad. Red.-Man.	0.23	0.18	0.81	0.46	2.86	0.99	7.85	2.85				
Cad. Red.-Auto.	0.20	0.17	0.56	0.28	2.77	1.37	6.00	3.52				
Hyd. Red.-Man.	0.30	0.20	0.60	0.16	2.95	0.59	7.47	2.04				
Hyd. Red.-Auto.	0.16	0.10	0.60	0.16	3.49	0.74	9.78	1.71				
Other	0.21	0.19	0.71	0.22	3.81	1.78	7.44	3.46				
True value	0.00		0.54		3.39		9.42					
NO_3^- Audit - 0277												
Cad. Red.-Man.	2.54	0.89	5.79	0.92	7.72	1.01	10.59	0.98				
Cad. Red.-Auto.	2.32	0.26	5.64	0.54	7.36	0.73	11.32	1.65				
Hyd. Red.-Man.	1.90	0.02	3.97	0.15	5.37	0.38	6.95	0.24				
Hyd. Red.-Auto	2.02	0.25	5.11	0.35	7.59	0.43	10.92	0.57				
Other	2.27	0.45	5.03	0.65	7.16	1.04	10.59	1.21				
True value	1.94		5.17		7.38		10.92					
NO_3^- Audit -0877												
Cad. Red.-Man.	0.51	0.62	1.62	0.95	1.53	0.45	3.93	1.55	5.13	1.15	6.76	1.26
Cad. Red.-Auto.	0.14	0.22	0.81	0.66	1.29	0.49	4.32	1.11	5.49	1.50	6.57	2.04
Hyd. Red.-Auto.	0.23	0.15	1.00	0.26	1.43	0.11	4.89	0.26	6.73	1.77	7.69	0.32
Other	0.51	1.24	0.81	0.36	1.28	0.52	3.78	1.90	4.96	1.96	6.06	2.42
True value	0.00		0.72		1.30		4.80		6.00		7.80	

Four analytical methods were used (plus a category, "Other"). Most of the samples were analyzed by methods in the "Other" category.

The overall results showed no bias between the reported and EPA values. The statistical distribution of the results appeared to be normal.

The automated hydrazine reduction method showed the best accuracy, while the manual hydrazine reduction procedure had the best precision.

The average slopes (Reported vs. EPA) for each audit ranged from 1.08 to 1.83. The intercept varied from -0.047 to -0.375.

HI-VOL LEAD

Participant Characteristics

Lead audit number 0877 began in August 1977. Out of 89 sample sets requested by participants, 67 sets of data were returned for a response rate of 75%. Table 41 indicates the monitoring agency type distribution.

TABLE 41. Pb AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
			Pb Audit - 0877			
Agencies Requesting Samples	0	6	45	31	7	89
Agencies Returning Data	0	5	33	25	4	67

Methods used to analyze the samples were grouped into four broad categories. Results were received from laboratories using two methods; these are listed in Table 42.

TABLE 42. Pb ANALYTICAL METHODS

Method	Number Agencies Using Method
Atomic Absorption	66
X-Ray Floresence	1

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting the use of the atomic absorption method procedure as the method of choice may have used that procedure with various modifications. Thus, Table 42 should be interpreted as meaning that 66 laboratories used procedures approximating the atomic absorption procedure.

A tabulation was made of the methods used to extract the material from the filter. Table 43 shows the various methods in use.

TABLE 43. Pb EXTRACTION PROCEDURES

Method	Number Agencies Using Method
Hot Acid Extraction	56
Cold Acid Extraction	3
Ultrasonication	1
Other	7

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample Ranges and Target Ranges are listed in Table 44. The ranges apply to sample concentrations in ascending order.

TABLE 44. Pb SAMPLE AND TARGET RANGES

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample Range	± 5%	± 5%	± 5%	± 5%	± 5%	± 5%
Target Range	± 10%	± 10%	± 10%	± 10%	± 10%	± 10%

Neither the Sample Ranges nor the Target Ranges were determined using the methods described under Statistical Approach. Both ranges were arbitrarily set at the values listed in Table 44. As more audits are conducted and more data become available, the ranges will be refined.

Using the above criteria, a tabulation was made of the number of agencies reporting results within the ranges. Thirty-two agencies (51%) reported five or six samples within the Target Ranges. Five laboratories (8%) reported all results outside the Target Ranges.

Data Summary

Using the Target Ranges as one means of eliminating nonrepresentative data, it was decided that any laboratory not reporting at least one value within the Target Ranges would be considered an outlier. The Target Ranges are sufficiently broad that, unless a laboratory is totally out of control, at least one value would fall within the ranges; this should occur if the laboratory is performing similarly to most of the study population. If the lab is not performing in a similar manner, its data should not be included in the summaries. Five laboratories met this criterion for outlier rejection and were eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

Table 45 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{Absolute Percent Difference} = \left|\frac{\text{Reported value - EPA value}}{\text{EPA value}}\right| \times 100 \cdot$$

The frequency distribution was then constructed and appears below. It should be noted that the "All Samples" line is not an average of the number appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

TABLE 45. Pb ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
					Pb Audit - 0877				
Concentration 1	51	0.0	0.6	3.9	5.6	10.0	45.0	327.8	20.0
Concentration 2	51	0.0	0.6	3.9	5.6	10.0	45.0	327.8	20.0
Concentration 3	51	0.0	0.7	2.5	5.4	11.1	23.5	250.6	16.0
Concentration 4	62	0.0	0.8	2.0	4.6	9.1	19.6	95.0	10.2
Concentration 5	62	0.0	0.2	2.0	4.9	7.9	13.1	91.7	9.5
Concentration 6	58	0.0	0.5	3.0	4.7	7.0	14.2	94.6	9.2
All Samples	284	0.0	0.7	2.8	5.4	9.1	23.5	327.8	12.6

Table 45 is very useful for laboratories trying to determine their performance relative to other participants. For example, only 10% of the labs reporting results for Concentration 2 had a percent difference of 0.6% or less, while 50% of the laboratories reported a percent difference of 5.6% or less for the same concentration. The Table also indicates that the average percent difference for all laboratories for all samples (except Concentration 1) was 12.6%.

Concentration 1 was a blank and was not included in the "All Samples" distribution. Because small concentration differences result in large percent differences, it was felt that the numbers would unduly distort the study results.

All data received (with the exception of the previously omitted data) were grouped according to concentration. Results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 46 and at the top of each listing in the Appendix do not include the five data sets identified as outliers.

Table 46 lists summary statistics based on reported data. The "Outliers Removed" column contains data on which an outlier test has been applied. All data that met the second criterion mentioned in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

With the exception of Concentration 1, the EPA determined "True value", and the mean and median of the study results agree well. This is indicated by the "Accuracy". The greatest difference is approximately 3.5%. The relatively poor agreement between the EPA and reported values for concentration 1 is an indication of the minimum detectable limits of the various analytical methods used during the audit.

Each laboratory data set was plotted against the corresponding EPA data set, and the slope and intercept from the linear regression were determined. The mean of 58 slopes was 1.138 with a standard deviation of 0.752. The mean intercept was 0.242 with a standard deviation of 0.898.

TABLE 46. Pb SUMMARY STATISTICS ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	a[3]	b[4]	a	b	a	b	a	b	a	b	a	b
							Pb Audit - 0877					
Number	28	27	51	50	51	50	62	60	62	59	58	56
True value	0.00	0.00	1.8	1.8	4.0	4.0	6.6	6.6	8.4	8.4	11.4	11.4
Mean	0.04	0.04	1.8	1.6	4.0	3.8	6.1	6.3	7.8	8.2	10.6	11.0
Median	0.03	0.03	1.8	1.8	4.0	4.0	6.4	6.4	8.2	8.3	11.0	11.0
Range	0.14	0.09	7.6	2.0	14.0	5.3	8.0	4.5	8.8	3.6	12.2	5.5
Std. Dev.	0.03	0.03	1.0	0.4	1.7	0.8	1.2	0.7	1.6	0.6	2.0	1.0
Coef. Var.	80.8	71.2	54.0	25.9	41.9	21.8	19.8	11.2	20.6	7.3	18.4	8.8
Skewness[1]	1.3	0.8	4.6	-2.1	4.1	-2.6	-2.9	-1.0	-3.3	-0.7	-3.4	-1.1
Accuracy[2]	-	-	-2.8	-2.8	-1.7	-2.0	-2.9	-2.6	-2.5	-1.6	-3.7	-3.5

[1] Skewness - A statistic that indicates the lack of symmetry in a distribution. For a Normal distribution this value is near zero.

[2] Accuracy - $$\frac{\text{Median - True value}}{\text{True value}} \times 100$$

[3] All Data

[4] Outliers Removed

Analytical Method Summary

A check was made to determine whether any relationship existed between the five laboratories that submitted data that were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). Table 47 resulted from this check.

TABLE 47. SUMMARY OF Pb ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total Number Using Method	Number Identified as Outliers	% of Total as Outliers
		Pb Audit - 0877	
Atomic Absorption	66	5	8%
X-Ray Floresence	1	-	0%

As can be seen, all of the outlier labs used the atomic absorption method. However, only one lab used another procedure.

To determine whether a particular analytical method produced biased results, Table 48 was developed. This table contains the means and standard deviations of each sample concentration for each method used.

TABLE 48. MEAN AND STANDARD DEVIATION OF Pb RESULTS BY ANALYTICAL METHOD ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
Method	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
	Pb Audit - 0877											
AA	0.02	0.03	1.77	0.95	3.93	1.76	6.16	1.18	7.81	1.62	10.62	1.96
XRF	0.00	-	0.85	-	3.10	-	3.80	-	8.40	-	12.60	-
True value	0.00		1.80		4.05		6.60		8.40		11.40	

The AA procedure produced the most accurate results at the lower concentrations. The XRF method had the least accurate results at the lower concen trations. The AA method, overall, produced the most accurate results.

Summary

The Pb Audit Survey 0877 began in August 1977. Eighty-nine laboratories requested samples, of which 67 returned results for a response rate of 75%. EPA, State, local, and private laboratories submitted data.

Two analytical methods were used. Ninety-nine percent of the laboratories used the atomic absorption procedure. One laboratory used the X-ray florescence method.

The overall agreement between the reported values and the EPA values was good. No bias was evident, and the results were normally distributed. The average percent difference between the EPA results and reported results was 12.6%. This figure does not include the blank data.

HI-VOL FLOW RATE

Participant Characteristics

Hi-Vol flow rate audit numbers 0576 and 0577 began in May 1976 and May 1977, respectively. Out of 175 agencies requesting to participate in audit number 0576, 146 responded with data, for a response rate of 83%. A total of 1,021 Hi-Vol units were tested. Out of 198 requests to participate in audit 0577, 167 agencies responded with data, for a response rate of 85%. A total of 1,016 Hi-Vol samplers were checked.

Table 49 indicates the monitoring agency type distribution.

TABLE 49. HI-Vol FlOW RATE AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
			Hi-Vol Audit - 0576			
Agencies Requesting ReF	1	11	64	98	1	175
Agencies Returning Data	1	7	53	84	1	146
			Hi-Vol Audit - 0577			
Agencies Requesting ReF	2	9	64	116	7	198
Agencies Returning Data	2	6	57	97	5	167

Methods used to measure the flow rate were grouped into three categories: rotameters, pressure transducers, and other. Table 50 lists the measurement methods and the number of units using the method.

TABLE 50. HI-VOL FLOW RATE MEASUREMENT METHODS

	Number Units Using Method	
	Audit 0576	Audit 0577
Rotameter	593	445
Pressure Transducer	344	395
Other	84	176

Table 50 indicates that a trend may be developing to move away from the rotameter measurement method to other more precise and accurate methods.

Acceptable Ranges

As described in a previous section, two ranges were used as one means of judging performance. The Sample Ranges and Target Ranges were calculated as ±5% and ±9%, respectively.

Using this criterion, a tabulation was made of the number of samplers reporting results within the ranges. For Study 0576, a total of 526 samplers (52%) reported four or five readings within the target ranges, while 168 units (16%) reported four or five readings outside the Target Ranges. Fifty-six agencies accounted for 108 units that reported all values outside the Target Ranges. The corresponding results for Study 0577 showed that 680 units (60%) reported four or five readings within the Target Ranges, while 101 units (10%) reported four or five readings outside the Target Ranges. Thirty-two agencies accounted for 74 units that reported all values outside the Target Ranges.

Data Summary

Table 51 is a frequency distribution of the percent difference between the reported and EPA values for each measurement pair. The differences were calculated using the following formula:

$$\text{Percent Difference} = \frac{\text{EPA value - Reported value}}{\text{EPA value}} .$$

An iterative routine was used to eliminate outliers while constructing the distribution. During each pass of the data, a check was performed to determine which reported values met the second criterion mentioned in Section 3. These values were removed, and the procedure repeated until no outliers were identified. This is the distribution that is titled "Outliers Removed" in Table 51. A total of six passes were required in audit 0576 to remove the outliers, while eight passes were required in audit 0577 to achieve the same results. As can be seen, 164 values were removed from audit 0576, while 204 values were removed from Study 0577.

TABLE 51. HI-VOL FLOW RATE PERCENT DIFFERENCES

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
					Hi-Vol Audit - 0576				
All Values	5014	-166	-12	-5	-1	2	9	68	-1
Outliers Removed	4850	-27	-11	-5	-1	2	8	24	-1
					Hi-Vol Audit - 0577				
All Values	4934	-504	-11	-4	-0.9	2	6	72	-2
Outliers Removed	4730	-23	-10	-4	-0.8	2	6	20	-1

As can be seen, removal of the outliers had little effect on the main body of the Table.

Table 51 is useful when evaluating the overall results of the audits. Excluding outliers, of all the observations reported for Audit 0577, 80% were within ±10% of the EPA calculated value. The overall average difference was -2%.

Histograms were constructed of all reported values for both audits and appear in Figures 19 and 20. As can be seen, there are slight negative bias (reported values higher than EPA). The distributions appear to be normal, with slight skewing to the negative side. However, considering the diversity of the measurement sources, the results appear well behaved and show excellent precision.

All reported value pairs for each audit were summarized using a linear regression equation of the form,

$$y = mx + b$$

where:

y = reported value

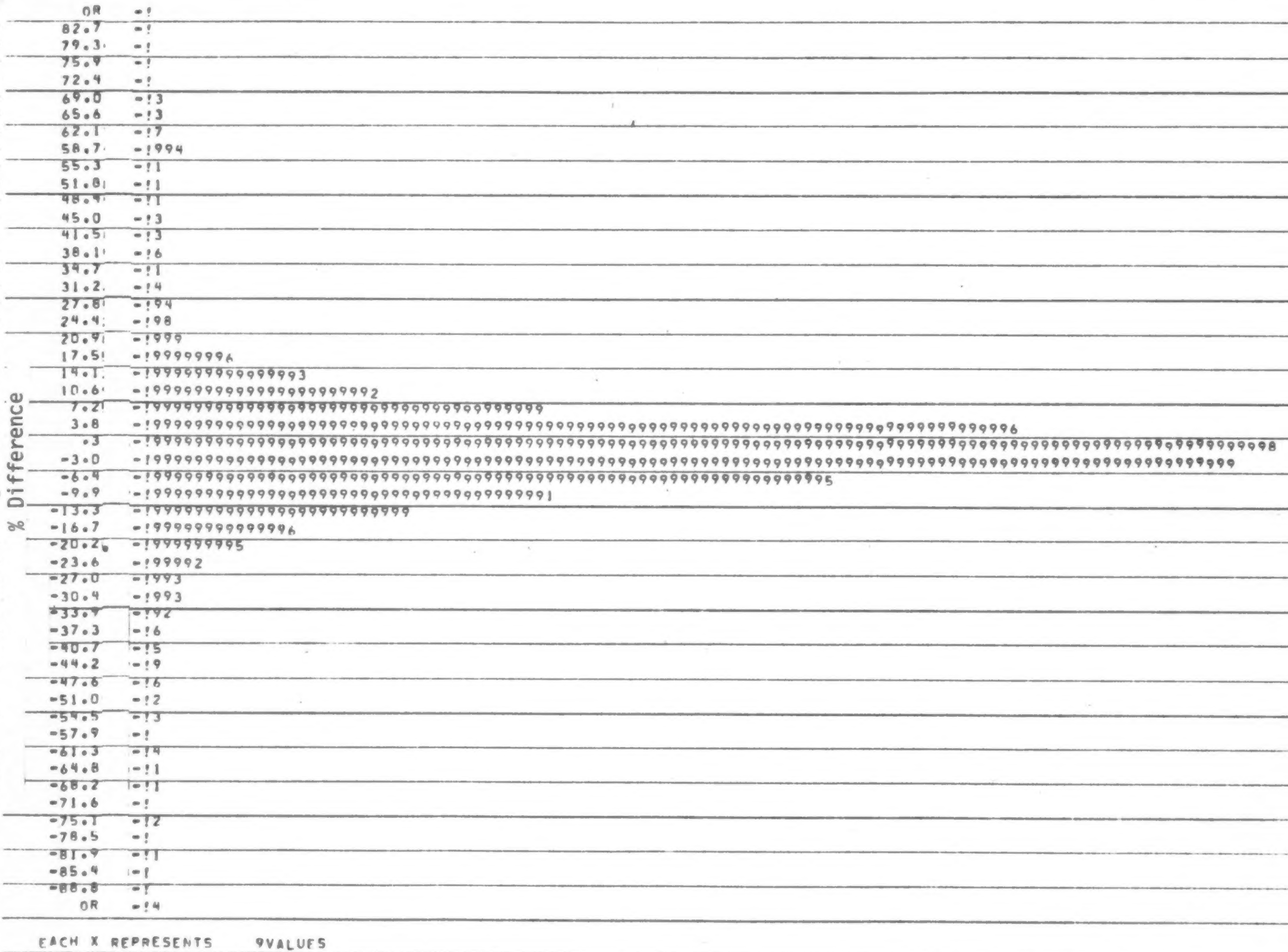


Figure 19. Hi-Vol flow rate histogram - 1976.

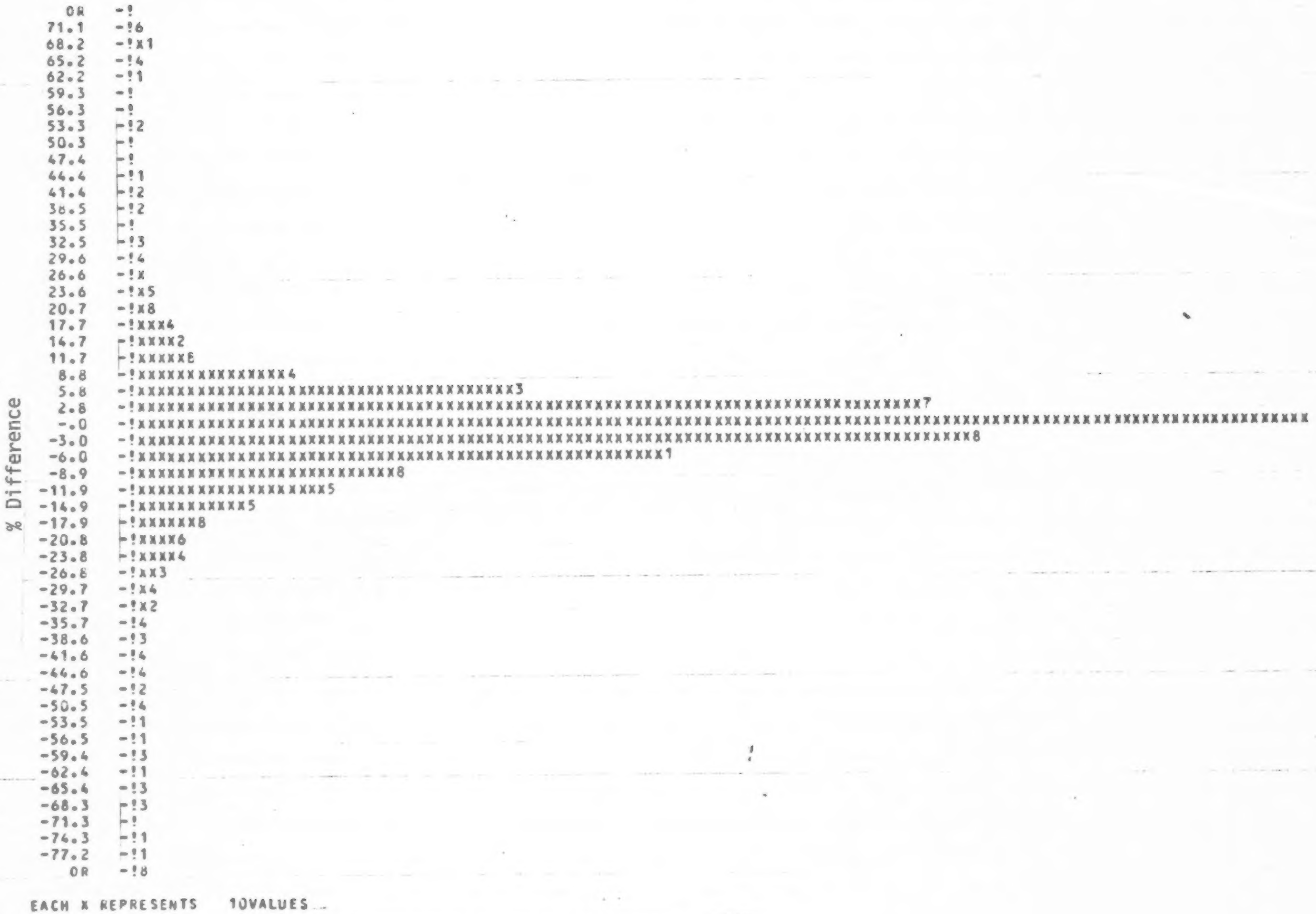


Figure 20. Hi-Vol flow rate histogram - 1977.

x = EPA value

The resulting equation for 0576 and 0577, respectively were:

$$y = 0.920\,x + 3.669 \quad (0576)$$

$$y = 0.936\,x + 3.204 \quad (0577)$$

The equations appear to indicate, because of the large intercept, a larger bias than actually exists. Since the equation is valid only over the range for which the test was conducted (30-60 ft^3/min), the influence of the intercept is not as great as is indicated.

Measurement Method Summary

To determine whether a measurement method produced biased results and to gain an indication of the accuracy and precision of the methods in use, the numbers in Table 51 were separated by method. Table 52 resulted.

TABLE 52. SUMMARY OF HI-VOL FLOW RATE MEASUREMENT METHODS

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
				Hi-Vol Audit - 0576					
Rotameter	2785	-29	-13	-6	-2	2	8	25	-2.1
P. Transducer	1665	-21	-8	-2	1	4	8	22	0.5
				Hi-Vol Audit - 0577					
Rotameter	2037	-26	-12	-5	-2	1	5	21	-2.8
P. Transducer	1870	-21	-9	-2	0.1	3	7	20	-0.2

The numbers generated in the above table are the result of several iterations similar to the ones needed to derive the "Outliers Removed" lines of Table 51.

It is obvious from Table 52 that the pressure transducer method of measurement is more accurate than the rotameter method. The table also shows that the apparent bias revealed in Table 51 is due almost entirely to the negative bias of the rotameter readings.

Forty-five percent of the units using the rotameter were able to report four or five values within the Target Ranges for audit 0576, while 60% of the units using the pressure transducer reported four or five values within the Target Ranges. Corresponding figures for Study 0577 showed 51% and 63%, respectively.

Linear regression equations for each method were derived as described in the preceding sections The resulting equations appear below:

Year	Equations	Measurement Method
1976	$y = 0.904 + 4.734$	rotameter
1976	$y = 0.924 + 2.568$	pressure transducer
1977	$y = 0.892 + 5.361$	rotameter
1977	$y = 0.951 + 2.161$	pressure transducer

As can be seen, the pressure transducer measurement pairs result in a slope closer to unity and an intercept closer to zero than do the rotameter pairs.

Summary

The Hi-Vol Flow Rate audits covered in this report started in May 1976 and May 1977. Number of participants ranged from 146 in 1976 to 167 in 1977. Foreign, EPA, State, local, and private laboratories submitted data.

The results from both audits showed a slight bias between EPA and reported results. The distributions were skewed slightly. Considering the number of units checked and the number of participating personnel, the bias and skewing are insignificant.

The slope of the equation representing all values for audit 0576 was 0.920 with an intercept of 3.669. The corresponding values for audit 0577 were 0.936 and 3.204.

SECTION 6

REFERENCES

1. Code of Federal Regulations (40 CFR) 50.11 Appendix A, pp. 5-11.

2. *Federal Register*, Vol. 38, No. 110, June 8, 1973, pp. 15175-15176.

3. Bromberg, S., Bennett, B., and Lampe, R. "Summary of Audit Performance, Measurement of SO_2, NO_2, Sulfate, Nitrate - 1976. EPA 600/4-78-004, January 1978.

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INTER-LABORATORY STUDY     1176

POLLUTANT - SO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                 128          RANGE            46.48         C.I.(UPPER)   18.35
TRUE-VALUE      19.13          VARIANCE         48.98         C.I.(LOWE  R)   15.93
MEAN            17.14          STD. DEV.         7.00         SKEWNESS          .52
MEDIAN          17.44          COEF. VAR.       40.84         ACCURACY        -8.85

DATA IN ASCENDING ORDER


        .07●          12.17          16.67          18.90          23.58
        .11●          12.73          16.70          18.92          23.58
        .14●          13.10          16.90          18.92          23.64
        .19           13.33          17.00          19.00          24.16
       1.13           13.39          17.00          19.50          25.67
       1.13           13.53          17.00          19.60          26.04●
       1.19           14.60          17.02          19.61          26.17
       2.35●          14.60          17.10          19.80          26.20
       2.62●          14.62          17.17          20.00          27.00
       2.62●          14.65          17.37          20.00          27.07
       2.66           14.93          17.50          20.00          27.38
       6.00           15.00          17.67          20.34          27.80
       6.08           15.32          17.81          20.60          28.48●
       7.00           15.33          18.00          20.67          29.82
       7.50           15.40          18.00          20.83          35.70●
       7.86           15.63          18.00          20.96          36.67
       7.85           15.72          18.22          20.96          40.75●
       7.85           15.72          18.34          20.96          41.20
       7.85           15.72          18.34          20.96          46.67
       8.34           15.72          18.34          20.96          52.40
       8.34           15.72          18.34          20.96          55.00●
       8.34           15.72          18.34          21.17          83.83●
       9.20           15.76          18.34          22.00         206.67●
       9.32●          15.80          18.43          22.20         275.10●
       9.52           16.30          18.53          22.20         464.56●
      11.00           16.33          18.67          22.27
      11.00           16.52          18.67          22.50
      11.10           16.67          18.70          23.00●
      11.11           16.67          18.75          23.00
      11.96           16.67          18.80          23.30
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INTER-LABORATORY STUDY     1176

POLLUTANT - SO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                133        RANGE          68.09        C.I.(UPPER)  45.56
TRUE-VALUE     43.03        VARIANCE       83.17        C.I.(LOWE  R)  42.46
MEAN           44.01        STD. DEV.       9.12        SKEWNESS       -.92
MEDIAN         44.75        COEF. VAR.     20.72        ACCURACY       4.00

DATA IN ASCENDING ORDER


         .06●         38.33          43.40          47.16          52.08
         .13●         38.33          43.68          47.16          52.25
         .16●         38.38          43.70          47.16          52.40
        2.62●         38.38          43.99          47.16          52.50
        3.30●         38.67          44.00          47.30          53.33
        4.11●         39.22          44.00          47.31          53.83
        5.24●         39.30          44.33          47.80          54.16
       10.26          39.30          44.54          47.90          54.60
       16.67          39.30          44.54          48.33          54.75
       21.00          39.30          44.54          48.97          55.02
       23.50          39.50          44.54          49.00          55.02
       25.18          39.93          44.61          49.00          57.57
       27.77          40.34          44.75          49.60          57.64
       28.82          40.83          45.13          49.78          57.80
       29.00          41.00          45.27          49.78          59.33
       29.00          41.00          45.33          49.83          60.76●
       29.50          41.13          45.33          50.00          61.00●
       31.44          41.66          45.38          50.00          66.82●
       31.44          41.66          45.60          50.00          68.60
       33.30          41.75          45.63          50.00          73.33
       33.37          41.83          45.70          50.00          73.48●
       34.06          41.92          45.80          50.08         100.60●
       35.24          41.92          46.09          50.17         119.30●
       36.00          41.92          46.67          50.27         193.33●
       36.10          42.00          46.67          50.57         235.80
       36.68          42.00          46.70          50.71         473.33●
       36.70          42.33          46.83          50.83         696.84●
       36.77          42.72          47.00          51.00         749.32●
       37.09          42.82          47.00          51.00
       38.00          43.30          47.00          51.33
       38.05          43.33          47.16          51.67
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INTER-LABORATORY STUDY     1176

POLLUTANT - SO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                  133        RANGE          127.53          C.I.(UPPER)   79.22
TRUE-VALUE       73.37        VARIANCE       175.02          C.I.(LOWE  R)   74.72
MEAN             76.97        STD. DEV.       13.23          SKEWNESS        -.76
MEDIAN           77.73        COEF. VAR.      17.19          ACCURACY        5.94

DATA IN ASCENDING ORDER


         .14●           68.48           76.00            80.70            86.46
         .15●           69.06           76.10            80.74            86.46
         .22●           69.50           76.33            80.74            86.67
        5.24●           70.07           76.45            81.22            87.00
        5.50●           70.10           76.57            81.22            88.90
       14.67●           70.30           76.60            81.22            88.90
       20.96●           70.74           76.70            81.22            89.00
       29.00●           71.00           77.00            81.67            89.08
       39.30            71.83           77.12            81.79            89.08
       41.10            72.10           77.17            82.59            89.10
       42.31            72.33           77.30            82.82            91.33
       54.74●           73.00           77.37            83.30            91.87
       55.50            73.36           77.73            83.33            99.56
       55.83            73.36           77.77            83.40            99.89
       58.10            73.36           77.92            83.67           103.37
       60.37            73.40           78.00            83.84           104.00●
       60.70            73.60           78.15            83.84           104.17●
       62.50            73.79           78.20            83.94           116.14●
       62.93            73.79           78.38            84.00           117.21●
       62.94            73.81           78.44            84.00           119.18●
       65.50            74.00           78.60            84.00           121.50
       65.67            74.65           79.00            84.00           132.77
       66.00            74.84           79.08            84.07           155.00●
       66.67            75.00           79.33            84.37           169.64●
       67.50            75.00           79.86            84.83           351.67●
       67.80            75.00           80.00            85.00           524.00
       68.00            75.10           80.10            85.00           803.33●
       68.12            75.10           80.20            85.50          1000.00●
       68.12            75.29           80.33            85.56
       68.12            75.35           80.50            86.46
       68.12            75.98           80.57            86.46
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INTER-LABORATORY STUDY    1176

POLLUTANT - SO2                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N               132         RANGE          992.13        C.I.(UPPER) 132.24
TRUE-VALUE   102.97         VARIANCE      6390.11        C.I.(LOWE  R) 104.96
MEAN         118.60         STD. DEV.       79.94        SKEWNESS      10.15
MEDIAN       111.82         COEF. VAR.      67.40        ACCURACY       8.59

DATA IN ASCENDING ORDER


       .18●        101.74        110.00        115.28        124.40
       .29●        103.48        110.04        115.33        124.67
       .36●        104.23        110.04        116.07        125.40
      7.86●        104.49        110.04        116.70        125.76
      9.90●        104.80        110.04        116.70        126.70
     48.00●        105.00        110.04        116.83        127.75
     49.78         105.00        110.04        116.87        128.38
     51.05●        105.00        111.00        117.33        129.25
     57.64●        105.17        111.22        117.86        130.21●
     72.60         105.73        111.38        118.33        133.33
     78.20         106.46        111.48        118.33        136.63
     78.60●        106.70        111.80        118.65        139.37●
     79.00         106.82        111.84        118.73        141.50
     79.16         106.88        111.84        118.80        144.10
     88.00         107.00        112.51        119.00        147.00●
     91.60         107.14        112.66        120.00        152.14
     91.70         107.42        112.66        120.00        163.21●
     91.87         107.57        113.00        120.00        176.40
     92.50         108.00        113.00        120.52        184.90●
     94.32         108.06        113.08        120.83        189.07●
     94.57         108.10        113.54        121.30        241.04
     95.50         108.50        113.67        121.83        241.65●
     96.94         109.00        113.90        122.00        505.00●
     97.87         109.00        113.97        122.46        602.60
     98.10         109.20        114.00        122.60        999.99
     99.17         109.33        114.00        122.93       1000.00●
     99.56         109.57        114.58        123.14       1000.00●
     99.90         109.77        114.93        123.14
     99.99         109.80        115.02        123.69
    100.48         110.00        115.28        124.00
    100.77         110.00        115.28        124.00
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INTER-LABORATORY STUDY     1176

POLLUTANT - SO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 129        RANGE          249.96          C.I.(UPPER) 160.59
TRUE-VALUE     149.03        VARIANCE       546.21          C.I.(LOWER) 152.52
MEAN           156.56        STD. DEV.       23.37          SKEWNESS     -1.90
MEDIAN         158.33        COEF. VAR.      14.93          ACCURACY      6.24

DATA IN ASCENDING ORDER


       .29●         146.72         154.58         162.44         172.00
       .42●         146.72         155.10         162.44         172.92
       .43●         146.72         155.53         162.56         173.00
       .94          148.00         155.56         163.00         173.76
     14.30●         148.61         156.25         163.22         175.00
     70.74          149.34         156.60         163.83         175.00
     91.00●         149.40         157.20         164.29         175.54
     97.41●         149.83         157.20         164.36         175.67
    102.18●         150.00         157.20         164.89         176.42
    106.54●         150.00         157.20         165.00         176.67
    123.08          150.00         157.20         165.06         175.85
    123.14          150.50         158.00         165.06         178.16
    123.15          150.57         158.33         165.06         180.00
    128.38          150.83         158.55         165.26         188.15●
    129.17          151.00         158.58         165.26         190.77
    131.00          151.00         158.92         166.00         190.97●
    131.67          151.17         159.30         166.31         202.00●
    131.77          151.96         159.37         166.67         213.17
    132.50          152.47         159.53         166.70         228.98
    133.20          152.50         159.78         166.70         243.73●
    133.62          152.51         159.82         167.33         244.50●
    135.88          152.56         159.82         167.96         247.56●
    137.00          153.00         159.83         168.52         250.90
    138.17          153.29         159.89         168.67         331.80●
    138.67          153.33         160.00         168.80         685.00●
    138.70          154.00         160.00         168.90        1000.00
    139.64          154.00         160.50         170.00        1000.00●
    145.30          154.00         160.83         170.30        1000.00●
    146.26          154.00         160.85         170.97
    146.66          154.10         161.90         171.40
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INTER-LABORATORY STUDY      477

POLLUTANT - SO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                134         RANGE         207.20          C.I.(UPPER)   23.20
TRUE-VALUE     21.90         VARIANCE      318.17          C.I.(LOWE  R)   17.16
MEAN           20.18         STD. DEV.      17.84          SKEWNESS       8.77
MEDIAN         18.30         COEF. VAR.     88.41          ACCURACY     -16.44

DATA IN ASCENDING ORDER


          .27●           14.44            17.36            19.50            23.58
         1.10            14.55            17.39            19.64            24.10
         2.62            14.82            17.80            19.80            25.00
         3.48            14.83            17.83            19.80            25.00
         3.78            14.94            17.90            19.92            25.98
         4.70            15.00            18.00            20.00            26.00
         4.93            15.00            18.00            20.04            26.20
         7.83●           15.44●           18.00            20.30            26.20
         8.34            15.72            18.00            20.34            26.20
         8.75            15.72            18.17            20.80            26.90
         9.76            15.82            18.25            20.80            27.52
        10.37            16.00            18.30            20.80            27.60
        10.48            16.04            18.30            20.96            28.82●
        10.48            16.10            18.30            20.96            30.63
        11.00●           16.13            18.30            20.96            31.44
        11.10            16.27            18.30            21.18            34.06
        11.80            16.33            18.30            21.33            34.06
        11.89            16.43            18.31            21.60            34.06
        11.90            16.55            18.34            22.00            38.53
        12.57            16.67            18.34            22.00            41.20
        13.10            16.67            18.34            22.00            41.67
        13.37            16.67            18.34            22.13            45.70
        13.83            16.70            18.54            22.22           188.64●
        13.99            16.70            18.81            22.49           208.30
        14.00            16.90            18.92            22.50
        14.00            17.00            19.00            22.78
        14.00            17.00            19.03            23.19
        14.28            17.14            19.09            23.20
        14.33            17.30            19.40            23.56
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INTER-LABORATORY STUDY      477

POLLUTANT - SO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N              138        RANGE          60.00        C.I.(UPPER)  46.65
TRUE-VALUE    48.23       VARIANCE       88.03        C.I.(LOWER)  43.52
MEAN          45.08       STD. DEV.       9.38        SKEWNESS       -.22
MEDIAN        45.22       COEF. VAR.     20.81        ACCURACY      -6.23

DATA IN ASCENDING ORDER


         .29●       39.30        43.67        46.90        52.40
       11.67        39.30        43.80        47.00        52.40
       13.20        39.44        44.00        47.00        52.40
       17.17●       40.00        44.00        47.00        52.40
       18.33●       40.00        44.17        47.00        53.50
       20.20        40.21        44.33        47.16        53.75
       24.00        40.30        44.34        47.16        54.00
       26.46        40.50        44.44        47.16        54.00
       27.90        40.70        44.54        47.16        54.98
       29.00        40.76        44.60        47.16        55.02
       32.88        41.00        44.95        48.00        59.42
       33.00        41.20        45.00        48.06        60.26
       33.15        41.20        45.00        48.09        60.26
       33.30        41.39        45.45        48.22        61.16
       33.40        41.70        45.66        48.40        61.30
       33.50        41.83        45.77        48.80        62.88
       34.06        41.92        45.80        48.83        65.20
       35.04        41.94        45.83        49.03        66.00
       35.50        42.33        46.00        49.29        67.00
       35.52●       42.67        46.15        49.60        68.30
       35.75        43.00        46.20        49.78        68.30
       36.68        43.00        46.25        49.78        71.67
       37.52        43.01        46.30        50.00        86.46●
       38.00        43.17        46.40        50.00       104.80●
       38.09        43.28        46.67        50.95       508.28●
       38.30        43.30        46.68        51.19
       38.37        43.30        46.70        51.50
       38.83        43.30        46.70        51.60
       39.17        43.33        46.70        51.96
       39.30        43.40        46.77        52.11
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INTER-LABORATORY STUDY      477

POLLUTANT - SO2                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 139        RANGE           74.20          C.I.(UPPER)   79.43
TRUE-VALUE      80.17        VARIANCE       130.28          C.I.(LOWER)   75.63
MEAN            77.53        STD. DEV.       11.41          SKEWNESS       -.92
MEDIAN          78.20        COEF. VAR.      14.72          ACCURACY      -2.46

DATA IN ASCENDING ORDER


          .32●          71.10          76.50          80.40          86.46
        17.28●          71.60          76.67          80.42          86.46
        30.80           72.00          76.70          80.48          86.61
        31.33           72.30          76.90          80.50          87.17
        39.40           72.50          77.00          80.52          87.80
        43.00           72.80          77.00          81.00          88.88
        44.40           72.81          77.15          81.22          89.01
        50.00           73.00          77.37          81.22          89.08
        51.59           73.00          77.47          81.22          90.00
        56.11           73.27          77.53          81.22          93.00
        58.10           73.36          77.75          81.40          93.23
        58.73           74.00          77.83          81.67          93.90
        61.73           74.20          78.00          82.00          94.30
        62.07●          74.70          78.20          82.00          94.32
        62.40           74.80          78.30          82.00          94.32
        62.88           74.90          78.30          82.05          94.80
        64.83           75.00          78.31          82.47          95.32
        66.70           75.00          78.40          83.30          95.65
        67.00           75.00          78.50          83.33          97.50
        67.33           75.00          78.50          83.84          99.00
        68.00           75.08          78.60          83.84         101.00
        69.05           75.20          78.60          83.84         104.17
        69.89           75.45          78.60          83.84         105.00
        70.00           75.50          78.60          83.84         196.50●
        70.10           75.50          78.62          84.18         254.14●
        70.10           75.56          78.62          84.70         937.96●
        70.52           75.73          79.00          84.89
        70.74           75.74          79.20          85.00
        70.74           75.90          79.20          85.31
        70.97           76.00          80.00          85.60
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INTER-LABORATORY STUDY      477

POLLUTANT - SO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 138          RANGE            86.06          C.I.(UPPER) 116.74
TRUE-VALUE     114.70          VARIANCE        174.17          C.I.(LOWE  R) 112.34
MEAN           114.54          STD. DEV.        13.20          SKEWNESS          .83
MEDIAN         113.00          COEF. VAR.       11.52          ACCURACY        -1.48

DATA IN ASCENDING ORDER


      .34●          105.80          111.02          115.28          124.58
    22.46●          106.70          111.10          115.45          125.66
    49.83●          106.82          111.11          115.68          126.67
    79.00           107.00          111.17          116.00          128.38
    80.90           107.00          111.17          116.60          129.46
    82.08           107.00          111.35          116.67          130.20
    87.36●          107.00          111.67          116.70          131.00
    91.06           107.10          111.70          116.88          131.00
    94.32           108.00          112.00          116.90          132.06
    96.94           108.00          112.66          117.50          132.83
    96.94           108.17          112.66          117.90          133.12
    96.94           108.51          112.69          117.90          133.32
    98.64           108.70          113.00          117.90          134.37
    98.95           109.20          113.00          117.90          134.77
    99.20           109.30          113.00          118.33          136.00
    99.54           109.50          113.06          118.39          140.67
    99.56           109.80          113.55          118.83          142.03
   100.10           109.90          113.80          118.91          147.00
   100.17           110.00          114.00          119.00          148.00
   100.50           110.00          114.27          119.37          154.00
   102.18           110.00          114.44          119.95          158.00
   103.23           110.00          114.46          120.00          165.06
   103.46           110.00          114.73          120.00          277.72●
   104.00           110.00          114.86          120.80          427.06●
   104.60           110.04          115.00          121.00         1000.00●
   104.80           110.17          115.01          122.70
   105.00           110.20          115.24          122.96
   105.00           110.66          115.27          123.14
   105.20           111.00          115.28          123.40
   105.43           111.00          115.28          124.10
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INTER-LABORATORY STUDY     477

POLLUTANT - SO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N              140        RANGE         158.00       C.I.(UPPER) 161.24
TRUE-VALUE  155.40        VARIANCE      453.31       C.I.(LOWER) 154.18
MEAN        157.71        STD. DEV.      21.29       SKEWNESS     -1.22
MEDIAN      158.21        COEF. VAR.     13.50       ACCURACY      1.81

DATA IN ASCENDING ORDER

        .39●      146.30      157.00      161.10      171.10
      31.86●      146.86      157.00      161.11      171.13
      51.00       147.00      157.20      161.50      172.96
      68.00●      147.42      157.20      161.62      173.30  ●
      72.00       148.00      157.20      161.67      173.61
     105.76       149.00      157.20      161.70      174.00
     108.00       149.00      157.20      162.00      174.07
     108.60       149.83      157.60      162.30      175.54
     112.66       149.90      157.67      162.44      176.66
     122.45●      150.22      157.95      162.58      177.50
     125.85       150.90      157.99      162.95      180.00
     128.38       151.00      158.00      164.82      183.93
     129.70       151.83      158.00      165.06      186.56
     131.00       151.86      158.13      165.40      188.09
     131.00       151.96      158.30      166.10      190.00
     131.77       151.96      158.40      166.20      191.26
     135.90       152.33      158.80      166.67      192.40
     137.50       153.00      159.00      167.00      195.58
     138.00       153.90      159.30      167.09      196.50
     141.36       154.23      159.30      167.68      200.00
     141.48       154.57      159.30      167.82      200.30
     141.48       155.00      159.82      168.50      204.00
     141.62       155.20      159.95      169.20      205.80
     142.50       155.20      160.00      169.67      209.00
     142.83       155.40      160.00      169.80      400.86●
     143.00       155.54      160.00      170.00      662.86●
     144.10       155.93      160.00      170.04     1000.00●
     145.00       156.05      160.00      170.30
     145.04       156.11      161.00      170.50
     145.16       156.83      161.00      171.02
```

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INTER-LABORATORY STUDY    1077

POLLUTANT - SO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                 114        RANGE          194.90        C.I.(UPPER)  18.49
TRUE-VALUE      13.60        VARIANCE       330.69        C.I.(LOWE  R)  11.81
MEAN            15.15        STD. DEV.       18.18        SKEWNESS        8.69
MEDIAN          13.10        COEF. VAR.     120.02        ACCURACY       -3.68

DATA IN ASCENDING ORDER

        .12●         8.18         11.83         14.50         20.37
        .15●         8.33         12.00         14.52         20.82
       1.57●         8.33         12.13         14.90         20.96
       1.60          8.52         12.24         15.00         20.96
       2.24●         8.56         12.94         15.10         21.50●
       2.56          8.65         13.00         15.46         21.70
       2.62          9.50         13.00         15.72         21.76
       2.62          9.70         13.10         15.72         21.96
       3.00          9.76●        13.10         15.72         22.20
       3.20          9.80         13.10         15.93         22.50
       3.31          9.87         13.10         16.09         23.00
       4.60●        10.31         13.10         16.10         23.58
       4.90         10.40         13.10         16.10         25.90
       5.00         10.48         13.30         16.60         26.20
       5.24         10.48         13.33         16.67         30.95
       5.24●        10.66         13.60         17.00         31.44
       6.00         10.80         13.60         17.20         31.74
       6.00         11.00         13.78         17.40         55.35●
       6.49         11.00         13.91         17.47        196.50
       6.80         11.17         13.92         17.97        864.60●
       6.90         11.50         14.00         18.34        899.20●
       7.20         11.57         14.00         19.02       1000.00●
       7.32         11.60         14.00         19.62       1000.00●
       7.86         11.66         14.10         20.00
       7.86         11.67         14.35         20.24
       8.00         11.70         14.41         20.34
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INTER-LABORATORY STUDY    1077

POLLUTANT - SO2
                                   UNITS - MICROGRAMS PER CUBIC METER
SAMPLE NUMBER -  2

N                 125        RANGE          441.60        C.I.(UPPER)  62.74
TRUE-VALUE      56.20        VARIANCE      1476.02        C.I.(LOWE  R)  49.27
MEAN            56.01        STD. DEV.       38.42        SKEWNESS        9.18
MEDIAN          53.93        COEF. VAR.      68.60        ACCURACY       -4.04

DATA IN ASCENDING ORDER

        .48●        44.54         51.70         55.02         60.30
        .57●        44.54         51.76         55.37         60.76
       5.49●        44.80         52.00         55.48         61.00
      11.17●        45.00         52.10         56.00         61.00
      16.70         45.25         52.20         56.31         61.15
      20.96         45.85         52.40         56.32         61.62
      20.96●        47.16         52.83         56.70         62.00
      21.60         47.16         52.98         56.94         62.96
      24.33         47.51         53.00         57.39         63.17
      25.94         47.56         53.17         57.50         63.47
      26.27●        47.60         53.56         57.60         66.60
      27.50         48.20         53.70         57.64         66.60
      30.17         48.70         53.89         57.64         66.76
      31.44         48.73         53.93         57.70         68.12
      35.00●        49.00         54.11         57.80         68.12
      36.00         49.08         54.20         58.30         69.80●
      36.65         49.11         54.33         58.60         88.35
      36.68         49.37         54.45         58.70         89.00
      37.94         49.44         54.50         58.80         94.32
      39.20         49.75         54.61         59.75        112.18
      39.60         49.78         54.80         59.90        172.96●
      39.74         49.78         55.00         60.00        419.20●
      40.20         50.00         55.00         60.10        458.30
      41.92         50.03         55.00         60.26       1000.00●
      42.30         50.50         55.02         60.26       1000.00●
      44.00         50.93         55.02         60.26       1000.00●
      44.20         51.00         55.02         60.26
      44.52         51.07         55.02         60.26
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INTER-LABORATORY STUDY    1077

POLLUTANT - SO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 126        RANGE           83.41        C.I.(UPPER)  93.40
TRUE-VALUE      93.73        VARIANCE       161.25        C.I.(LOWE  R)  88.97
MEAN            91.18        STD. DEV.       12.70        SKEWNESS       -1.19
MEDIAN          91.70        COEF. VAR.      13.93        ACCURACY       -2.17

DATA IN ASCENDING ORDER

        .84●        83.33         90.86         95.10        100.00
        .90●        83.50         91.00         95.17        100.70
       9.36●        83.84         91.27         95.40        100.91
      20.11●        83.84         91.47         95.67        101.56
      39.30●        83.84         91.55         96.00        101.67
      39.73         84.32         91.63         96.25        102.00
      44.44●        85.40         91.66         96.30        102.00
      45.64         85.60         91.70         96.62        102.25
      46.70         86.46         91.70         96.70        102.50
      50.00●        86.46         91.70         96.80        103.30
      58.30         86.46         91.70         96.94        104.80
      64.86         87.00         91.70         97.00        105.70
      68.12         87.00         91.70         97.13        106.00
      68.33         87.20         91.70         97.30        106.00
      69.57         87.69         91.70         97.40        110.04
      71.50         88.10         91.80         98.00        111.00
      75.20         88.50         92.00         98.00        111.70
      75.98         88.96         92.85         98.30        111.94
      76.78         89.33         93.18         98.33        113.03
      77.40         89.37         93.20         98.49        121.68
      77.95         89.65         93.96         99.00        123.14
      78.00         90.00         94.10         99.00        145.10●
      78.40         90.00         94.32         99.10        252.52●
      78.60         90.30         94.32         99.30        432.84●
      78.70         90.33         94.32         99.42        759.80●
      82.01         90.42         94.32         99.56       1000.00●
      82.10         90.42         94.40         99.67       1000.00●
      83.00         90.50         94.90         99.83
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INTER-LABORATORY STUDY    1077

POLLUTANT - SO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 125      RANGE          131.08       C.I.(UPPER)  96.19
TRUE-VALUE      93.73      VARIANCE       214.10       C.I.(LOWE  R)  91.06
MEAN            33.63      STD. DEV.       14.63       SKEWNESS         .87
MEDIAN          94.32      COEF. VAR.      15.63       ACCURACY         .63

DATA IN ASCENDING ORDER


       .82●          85.82             91.70             96.07            104.00
      1.02●          86.00             92.00             96.11            104.10
      9.41●          86.09             92.82             96.80            105.00
     19.06●          86.40             93.01             96.94            106.00
     39.30●          86.57             93.06             97.00            106.58
     46.13           87.00             93.20             97.33            106.70
     53.30           87.31             93.50             97.34            107.00
     53.80           88.00             93.50             97.40            108.09
     57.26           88.10             93.92             97.51            110.04
     57.69           88.30             93.96             98.00            110.71
     63.30●          88.30             94.29             98.20            111.00
     70.00           88.83             94.32             98.40            111.94
     72.52           89.00             94.32             98.49            113.00
     73.36           89.08             94.32             98.70            114.21
     75.20           89.08             94.32             99.00            115.10
     77.50           89.08             94.32             99.12            120.59
     78.00           89.08             94.32             99.30            121.10
     78.96           89.33             94.32             99.56            128.38
     80.80           89.83             94.32             99.56            161.20●
     81.22           90.00             94.64             99.56            177.21
     81.22           90.00             95.00             99.67            342.46●
     83.31           90.80             95.00             99.83            864.60●
     83.84           91.00             95.00            100.00           1000.00●
     84.10           91.20             95.00            100.00           1000.00●
     84.50           91.47             95.24            100.00           1000.00●
     84.90           91.67             95.42            101.83
     85.50           91.70             95.58            102.18
     85.55           91.70             96.00            103.00
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INTER-LABORATORY STUDY     1077

POLLUTANT - SO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  124        RANGE          995.03         C.I.(UPPER) 188.59
TRUE-VALUE      179.07        VARIANCE      6644.76         C.I.(LOWER) 159.89
MEAN            174.28        STD. DEV.       81.52         SKEWNESS      8.14
MEDIAN          172.92        COEF. VAR.      46.78         ACCURACY     -3.43

DATA IN ASCENDING ORDER


      1.61●        162.70        170.30        178.16        187.00
      1.90●        163.70        170.30        178.25        187.05
      4.97         164.04        170.91        178.50        187.35
     15.40         164.30        171.00        178.54        187.50
     17.73●        164.60        171.72        178.61        188.17
     22.20         164.62        172.43        178.80        188.30
     36.68         164.94        172.57        178.96        188.64
     38.51●        165.00        172.60        179.00        188.64
     70.74●        165.00        172.92        179.49        191.26
     82.30●        165.06        172.92        179.65        192.00
     83.33         165.45        172.92        179.90        193.00
     96.52         165.65        172.92        180.00        196.50
    125.00         165.70        172.92        180.91        197.17
    132.04         166.34        172.92        180.91        200.00
    133.65         167.00        172.92        181.00        209.60
    138.10         167.00        173.59        181.00        210.00
    140.80●        167.23        173.70        181.50        210.30
    141.05         167.68        175.42        182.64        211.60
    143.30         167.68        175.50        182.92        258.00●
    149.76         168.00        175.54        183.30        480.83●
    150.00         168.30        175.54        183.33       1000.00●
    151.15         168.30        175.54        183.35       1000.00●
    155.30         168.34        175.68        183.40       1000.00●
    157.20         168.83        176.00        184.33       1000.00●
    159.67         169.36        176.42        185.00       1000.00●
    160.00         169.39        176.70        186.00
    161.00         170.10        177.68        186.67
    162.44         170.30        177.80        186.70
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INTER-LABORATORY STUDY     1276

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                106        RANGE               .17       C.I.(UPPER)     .12
TRUE-VALUE       .12        VARIANCE            .00       C.I.(LOWER)       .11
MEAN             .12        STD. DEV.           .03       SKEWNESS        .17
MEDIAN           .12        COEF. VAR.        22.52       ACCURACY        .00
DATA IN ASCENDING ORDER


       .04           .10           .12           .13           .14
       .05           .10           .12           .13           .14
       .05           .10           .12           .13           .14
       .06           .10           .12           .13           .14
       .06           .10           .12           .13           .14
       .07           .11           .12           .13           .14
       .09           .11           .12           .13           .15
       .09           .11           .12           .13           .15
       .09           .11           .12           .13           .15
       .09           .11           .12           .13           .15
       .09           .11           .12           .13           .16
       .09           .11           .12           .13           .16
       .09           .11           .12           .13           .16
       .09           .11           .12           .13           .16
       .09           .11           .12           .13           .17
       .09           .11           .12           .13           .18
       .10           .11           .12           .13           .19
       .10           .11           .12           .13           .20
       .10           .11           .12           .14           .22
       .10           .12           .12           .14           .24
       .10           .12           .12           .14
       .10           .12           .12           .14
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INTER-LABORATORY STUDY     1276

POLLUTANT - NO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                 105          RANGE              .24         C.I.(UPPER)      .18
TRUE-VALUE        .18          VARIANCE           .00         C.I.(LOWE  R)      .17
MEAN              .17          STD. DEV.          .03         SKEWNESS        -.73
MEDIAN            .17          COEF. VAR.       16.48         ACCURACY       -3.87

DATA IN ASCENDING ORDER


         .03               .16               .17               .18               .20
         .11               .16               .17               .18               .20
         .11               .16               .17               .18               .20
         .12               .16               .17               .18               .20
         .13               .16               .17               .18               .20
         .14               .16               .17               .18               .20
         .14               .16               .17               .19               .20
         .14               .16               .17               .19               .20
         .14               .16               .17               .19               .20
         .14               .16               .17               .19               .21
         .14               .16               .17               .19               .21
         .15               .16               .18               .19               .21
         .15               .16               .18               .19               .21
         .15               .16               .18               .19               .22
         .15               .17               .18               .19               .23
         .15               .17               .18               .20               .25
         .15               .17               .18               .20               .27
         .15               .17               .18               .20               .34●
         .16               .17               .18               .20               .46●
         .16               .17               .18               .20
         .16               .17               .18               .20
         .16               .17               .18               .20
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INTER-LABORATORY STUDY    1276

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N               108         RANGE             .20         C.I.(UPPER)      .33
TRUE-VALUE      .33         VARIANCE          .00         C.I.(LOWE  R)     .32
MEAN            .32         STD. DEV.         .03         SKEWNESS         .07
MEDIAN          .32         COEF. VAR.      10.37         ACCURACY        -.61

DATA IN ASCENDING ORDER


        .23          .30          .32          .33          .35
        .23          .30          .32          .33          .35
        .24          .30          .32          .33          .35
        .24          .31          .32          .33          .35
        .25          .31          .32          .33          .35
        .25          .31          .32          .33          .35
        .27          .31          .32          .34          .36
        .27          .31          .32          .34          .36
        .28          .31          .32          .34          .36
        .28          .31          .32          .34          .37
        .28          .31          .33          .34          .37
        .29          .31          .33          .34          .38
        .29          .31          .33          .34          .40
        .29          .32          .33          .34          .41
        .30          .32          .33          .34          .43
        .30          .32          .33          .34          .43
        .30          .32          .33          .34          .47
        .30          .32          .33          .34          .57
        .30          .32          .33          .34
        .30          .32          .33          .34
        .30          .32          .33          .34
        .30          .32          .33          .34
        .30          .32          .33          .35
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INTER-LABORATORY STUDY     1276

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                108          RANGE              .36          C.I.(UPPER)      .52
TRUE-VALUE       .54          VARIANCE           .00          C.I.(LOWER)      .51
MEAN             .52          STD. DEV.          .05          SKEWNESS         .60
MEDIAN           .52          COEF. VAR.        9.40          ACCURACY       -2.99

DATA IN ASCENDING ORDER


        .39              .48              .51              .53              .56
        .39              .48              .51              .53              .56
        .40              .49              .51              .53              .56
        .41              .49              .51              .54              .56
        .43              .49              .52              .54              .56
        .44              .49              .52              .54              .57
        .45              .49              .52              .54              .57
        .45              .49              .52              .54              .57
        .45              .49              .52              .54              .57
        .45              .50              .52              .54              .58
        .45              .50              .52              .55              .58
        .45              .50              .52              .55              .58
        .46              .50              .52              .55              .59
        .46              .50              .52              .55              .59
        .45              .50              .52              .55              .59
        .47              .50              .52              .55              .66●
        .47              .50              .52              .55              .75
        .47              .50              .52              .55              .96●
        .48              .50              .52              .55
        .48              .50              .52              .55
        .48              .50              .53              .55
        .48              .50              .53              .56
        .48              .51              .53              .56
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INTER-LABORATORY STUDY     1276

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 107        RANGE               .54          C.I.(UPPER)     .86
TRUE-VALUE        .87        VARIANCE            .00          C.I.(LOWE  R)     .84
MEAN              .85        STD. DEV.           .07          SKEWNESS         .48
MEDIAN            .86        COEF. VAR.         7.34          ACCURACY       -1.51

DATA IN ASCENDING ORDER


          .63              .81              .85              .87              .89
          .70              .81              .85              .87              .89
          .72              .81              .85              .87              .89
          .72              .82              .85              .87              .90
          .73              .82              .85              .87              .90
          .73              .82              .85              .87              .90
          .74              .82              .85              .87              .90
          .75              .83              .86              .87              .90
          .75              .83              .86              .88              .90
          .75              .83              .86              .88              .91
          .75              .83              .86              .88              .92
          .77              .84              .86              .88              .93
          .78              .84              .86              .88              .93
          .79              .84              .86              .88              .94
          .79              .84              .86              .88              .96
          .79              .84              .86              .88              .98
          .80              .84              .86              .88             1.00
          .80              .84              .86              .88             1.01
          .80              .85              .86              .88             1.15●
          .80              .85              .87              .89             1.17
          .80              .85              .87              .89             1.67●
          .81              .85              .87              .89
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INTER-LABORATORY STUDY     677

POLLUTANT - NO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                 94        RANGE             .15        C.I.(UPPER)    .13
TRUE-VALUE       .12        VARIANCE          .00        C.I.(LOWE  R)    .12
MEAN             .13        STD. DEV.         .02        SKEWNESS     -1.39
MEDIAN           .13        COEF. VAR.      17.51        ACCURACY      8.40

DATA IN ASCENDING ORDER

        .01●          .12          .13          .13          .14
        .01●          .12          .13          .13          .14
        .03           .12          .13          .13          .14
        .04           .12          .13          .13          .14
        .07           .12          .13          .13          .14
        .08           .12          .13          .13          .14
        .09           .12          .13          .13          .14
        .09           .12          .13          .13          .14
        .10           .12          .13          .13          .15
        .10           .12          .13          .13          .15
        .10           .12          .13          .13          .15
        .11           .12          .13          .14          .17
        .11           .12          .13          .14          .17
        .11           .12          .13          .14          .17
        .11           .12          .13          .14          .18
        .11           .13          .13          .14          .18
        .12           .13          .13          .14
        .12           .13          .13          .14
        .12           .13          .13          .14
        .12           .13          .13          .14
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INTER-LABORATORY STUDY      677

POLLUTANT - NO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  97       RANGE              .30       C.I.(UPPER)     .25
TRUE-VALUE        .24       VARIANCE           .00       C.I.(LOWE  R)      .24
MEAN              .25       STD. DEV.          .03       SKEWNESS       1.73
MEDIAN            .25       COEF. VAR.       11.86       ACCURACY       4.20

DATA IN ASCENDING ORDER

     .02●         .23          .24          .25          .26
     .02●         .24          .25          .25          .26
     .13          .24          .25          .25          .26
     .17          .24          .25          .25          .26
     .19          .24          .25          .25          .26
     .20          .24          .25          .25          .27
     .21          .24          .25          .25          .27
     .21          .24          .25          .25          .27
     .21          .24          .25          .26          .27
     .22          .24          .25          .26          .27
     .22          .24          .25          .26          .27
     .23          .24          .25          .26          .28
     .23          .24          .25          .26          .28
     .23          .24          .25          .26          .28
     .23          .24          .25          .26          .29
     .23          .24          .25          .26          .29
     .23          .24          .25          .26          .29
     .23          .24          .25          .26          .29
     .23          .24          .25          .26          .43
     .23          .24          .25          .26
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INTER-LABORATORY STUDY      677

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                  92        RANGE             .26          C.I.(UPPER)     .26
TRUE-VALUE        .24        VARIANCE          .00          C.I.(LOWE  R)      .25
MEAN              .25        STD. DEV.         .03          SKEWNESS       2.11
MEDIAN            .25        COEF. VAR.      11.59          ACCURACY       2.46

DATA IN ASCENDING ORDER


         .02●           .23            .25            .25            .27
         .02●           .24            .25            .25            .27
         .17            .24            .25            .25            .27
         .18            .24            .25            .25            .27
         .19            .24            .25            .25            .27
         .20            .24            .25            .25            .27
         .21            .24            .25            .26            .27
         .21            .24            .25            .26            .27
         .21            .24            .25            .26            .28
         .23            .24            .25            .26            .28
         .23            .24            .25            .26            .28
         .23            .24            .25            .26            .28
         .23            .24            .25            .26            .29
         .23            .25            .25            .26            .29
         .23            .25            .25            .26            .29
         .23            .25            .25            .26            .30
         .23            .25            .25            .26            .30
         .23            .25            .25            .26            .43
         .23            .25            .25            .26
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INTER-LABORATORY STUDY      677

POLLUTANT - NO2                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                  99       RANGE            .54     C.I.(UPPER)     .40
TRUE-VALUE        .38       VARIANCE         .00     C.I.(LOWE  R)    .38
MEAN              .39       STD. DEV.        .05     SKEWNESS       1.16
MEDIAN            .39       COEF. VAR.     14.12     ACCURACY       2.38

DATA IN ASCENDING ORDER

        .03●          .37          .38          .39          .41
        .04●          .37          .38          .39          .41
        .13           .37          .38          .39          .41
        .30           .37          .38          .39          .41
        .31           .38          .38          .39          .42
        .31           .38          .38          .39          .42
        .32           .38          .38          .39          .42
        .32           .38          .39          .39          .42
        .32           .38          .39          .39          .43
        .34           .38          .39          .40          .43
        .34           .38          .39          .40          .43
        .35           .38          .39          .40          .43
        .35           .38          .39          .40          .45
        .35           .38          .39          .40          .46
        .36           .38          .39          .40          .48
        .36           .38          .39          .40          .55
        .36           .38          .39          .40          .66
        .37           .38          .39          .40
        .37           .38          .39          .40
        .37           .38          .39          .41
        .37           .38          .39          .41
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INTER-LABORATORY STUDY     677

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 96        RANGE            .71         C.I.(UPPER)     .73
TRUE-VALUE       .69        VARIANCE         .00         C.I.(LOWE  R)     .70
MEAN             .71        STD. DEV.        .07         SKEWNESS       3.82
MEDIAN           .71        COEF. VAR.      9.42         ACCURACY       2.75

DATA IN ASCENDING ORDER

          .07●          .69          .70          .72          .74
          .07●          .69          .70          .72          .74
          .50           .69          .70          .72          .75
          .57           .69          .70          .72          .75
          .59           .69          .71          .72          .75
          .64           .69          .71          .72          .75
          .65           .70          .71          .72          .75
          .65           .70          .71          .72          .75
          .65           .70          .71          .72          .76
          .66           .70          .71          .72          .76
          .66           .70          .71          .73          .77
          .67           .70          .71          .73          .77
          .67           .70          .71          .73          .78
          .68           .70          .71          .73          .79
          .68           .70          .71          .73          .80
          .69           .70          .71          .73          .80
          .69           .70          .71          .73          .81
          .69           .70          .71          .73         1.21
          .69           .70          .71          .74
          .69           .70          .71          .74
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INTER-LABORATORY STUDY     1277

POLLUTANT - NO2                           UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   96        RANGE              .36        C.I.(UPPER)      .19
TRUE-VALUE         .18        VARIANCE           .00        C.I.(LOWE  R)      .18
MEAN               .18        STD. DEV.          .04        SKEWNESS        -.11
MEDIAN             .18        COEF. VAR.       21.68        ACCURACY        1.93

DATA IN ASCENDING ORDER


        .01             .17             .18             .19             .20
        .08             .17             .18             .19             .20
        .09             .18             .18             .19             .20
        .11             .18             .18             .19             .21
        .11             .18             .18             .19             .21
        .12             .18             .18             .19             .22
        .13             .18             .18             .19             .22
        .13             .18             .18             .19             .22
        .14             .18             .19             .19             .22
        .15             .18             .19             .19             .23
        .15             .18             .19             .19             .24
        .15             .18             .19             .19             .24
        .15             .18             .19             .19             .25
        .15             .18             .19             .19             .26
        .15             .18             .19             .20             .27
        .17             .18             .19             .20             .37
        .17             .18             .19             .20             .40●
        .17             .18             .19             .20           9.00●
        .17             .18             .19             .20
        .17             .18             .19             .20
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INTER-LABORATORY STUDY     1277

POLLUTANT - NO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                 98        RANGE              .20          C.I.(UPPER)     .33
TRUE-VALUE       .31        VARIANCE           .00          C.I.(LOWE  R)     .31
MEAN             .32        STD. DEV.          .04          SKEWNESS       -.46
MEDIAN           .32        COEF. VAR.       11.09          ACCURACY       4.18

DATA IN ASCENDING ORDER


        .10●          .30          .32          .33          .34
        .22           .31          .32          .33          .35
        .23           .31          .32          .33          .35
        .24           .31          .32          .33          .35
        .24           .31          .32          .33          .35
        .25           .31          .32          .33          .36
        .25           .31          .32          .33          .36
        .25           .31          .32          .33          .36
        .25           .31          .32          .33          .37
        .25           .32          .32          .33          .37
        .26           .32          .32          .33          .37
        .26           .32          .32          .33          .38
        .27           .32          .32          .34          .39
        .29           .32          .32          .34          .42
        .29           .32          .32          .34          .42
        .29           .32          .32          .34          .66●
        .30           .32          .32          .34       15.00●
        .30           .32          .33          .34
        .30           .32          .33          .34
        .30           .32          .33          .34
        .30           .32          .33          .34
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INTER-LABORATORY STUDY    1277

POLLUTANT - NO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                   99        RANGE              .57       C.I.(UPPER)     .52
TRUE-VALUE         .50        VARIANCE           .00       C.I.(LOWE  R)     .50
MEAN               .51        STD. DEV.          .06       SKEWNESS         .91
MEDIAN             .52        COEF. VAR.       11.84       ACCURACY        4.23

DATA IN ASCENDING ORDER


          .16●          .50          .52          .52          .54
          .29           .50          .52          .52          .54
          .36           .50          .52          .52          .54
          .37           .51          .52          .52          .55
          .38           .51          .52          .53          .55
          .39           .51          .52          .53          .55
          .39           .51          .52          .53          .55
          .40           .51          .52          .53          .56
          .41           .51          .52          .53          .56
          .41           .51          .52          .53          .56
          .43           .51          .52          .53          .57
          .45           .51          .52          .53          .57
          .47           .51          .52          .53          .57
          .48           .51          .52          .53          .57
          .48           .51          .52          .53          .59
          .48           .51          .52          .53          .87
          .49           .51          .52          .53         1.06●
          .49           .51          .52          .53        25.00●
          .49           .51          .52          .54
          .50           .51          .52          .54
          .50           .52          .52          .54
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INTER-LABORATORY STUDY    1277

POLLUTANT - NO2                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 98        RANGE             .69        C.I.(UPPER)     .53
TRUE-VALUE       .50        VARIANCE          .00        C.I.(LOWE  R)    .50
MEAN             .52        STD. DEV.         .07        SKEWNESS       3.33
MEDIAN           .52        COEF. VAR.      13.46        ACCURACY       2.98

DATA IN ASCENDING ORDER


          .18●          .50          .52          .52          .54
          .33           .50          .52          .52          .55
          .37           .50          .52          .52          .55
          .38           .50          .52          .53          .55
          .39           .50          .52          .53          .56
          .40           .51          .52          .53          .56
          .40           .51          .52          .53          .56
          .40           .51          .52          .53          .57
          .41           .51          .52          .53          .57
          .42           .51          .52          .53          .57
          .44           .51          .52          .53          .57
          .45           .51          .52          .53          .58
          .48           .51          .52          .53          .58
          .48           .51          .52          .53          .59
          .48           .51          .52          .53         1.02
          .49           .51          .52          .54         1.06●
          .50           .51          .52          .54        25.00●
          .50           .51          .52          .54
          .50           .52          .52          .54
          .50           .52          .52          .54
          .50           .52          .52          .54
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INTER-LABORATORY STUDY    1277

POLLUTANT - NO2                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 100       RANGE           1.09       C.I.(UPPER)      .89
TRUE-VALUE        .87       VARIANCE         .01       C.I.(LOWE  R)     .85
MEAN              .87       STD. DEV.        .11       SKEWNESS      -4.75
MEDIAN            .89       COEF. VAR.     12.37       ACCURACY       2.24

DATA IN ASCENDING ORDER

        .03          .85          .88          .90          .93
        .36●         .85          .88          .90          .93
        .70          .85          .88          .90          .93
        .70          .86          .88          .90          .94
        .70          .86          .88          .90          .94
        .72          .86          .88          .90          .95
        .72          .86          .89          .90          .95
        .73          .86          .89          .90          .95
        .74          .87          .89          .91          .95
        .74          .87          .89          .91          .96
        .75          .87          .89          .91          .96
        .77          .88          .89          .91          .97
        .80          .88          .89          .91          .97
        .81          .88          .89          .91          .97
        .81          .88          .89          .91          .98
        .82          .88          .89          .92          .99
        .83          .88          .89          .92         1.12
        .84          .88          .89          .92         1.83●
        .84          .88          .90          .92        43.00●
        .85          .88          .90          .92
        .85          .88          .90          .92
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INTER-LABORATORY STUDY    1076

POLLUTANT - CO                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                 228        RANGE           40.89          C.I. (UPPER)    5.11
TRUE-VALUE       4.51        VARIANCE        13.65          C.I. (LOWER)    4.15
MEAN             4.63        STD. DEV.        3.69          SKEWNESS        9.00
MEDIAN           4.30        COEF. VAR.      79.76          ACCURACY       -4.66

DATA IN ASCENDING ORDER


     1.00● 3.70     3.80   4.10    4.20    4.47    4.50     4.65   4.73 42.49
     1.50● 3.70     3.80   4.10    4.20    4.50    4.50     4.69   4.75 43.31●
     1.60  3.70     3.80   4.10    4.20    4.50    4.50     4.70   4.75
     2.00● 3.75     3.80   4.10    4.20    4.50    4.50     4.70   4.85
     2.00  3.75     3.81   4.10    4.20    4.50    4.50     4.70   4.90
     2.00  3.80     3.85   4.10    4.20    4.50    4.50     4.70   4.90
     2.80  3.80     3.90   4.14    4.20    4.50    4.50     4.72   5.00
     2.80           3.90           4.20            4.50            5.00
     2.90           3.90           4.20            4.50            5.00
     3.00           3.90           4.20            4.50            5.00
     3.00           3.90           4.20            4.50            5.00
     3.20●          3.91           4.22            4.50            5.00
     3.20           3.99           4.23            4.50            5.00
     3.20           4.00           4.25            4.50            5.00
     3.20           4.00           4.25            4.50            5.00
     3.30           4.00           4.25            4.50            5.00
     3.30           4.00           4.25            4.50            5.00
     3.39           4.00           4.25            4.50            5.00
     3.40●          4.00           4.25            4.50            5.00
     3.40           4.00           4.25            4.50            5.00
     3.48           4.00           4.26            4.50            5.00
     3.49●          4.00           4.30            4.50            5.09●
     3.50●          4.00           4.30            4.50            5.10
     3.50           4.00           4.30            4.50            5.15
     3.50           4.00           4.30            4.50            5.20
     3.50           4.00           4.30            4.50            5.20
     3.50           4.00           4.30            4.50            5.22●
     3.50           4.00           4.30            4.50            5.30
     3.50           4.00           4.31            4.50            5.33●
     3.50           4.00           4.33            4.50            5.36
     3.50           4.00           4.35            4.53            5.40
     3.50           4.00           4.35            4.55            5.50
     3.50           4.00           4.35            4.60            5.50
     3.55           4.00           4.40            4.60            5.60●
     3.57           4.00           4.40            4.60            5.70
     3.58           4.00           4.40            4.60            5.76●
     3.60           4.00           4.40            4.60            6.00●
     3.60           4.00           4.41            4.60            6.00
     3.60           4.00           4.42            4.60            6.01
     3.60           4.00           4.44            4.60            6.25●
     3.67           4.03           4.45            4.61           21.85
     3.69           4.08           4.45            4.62           23.48●
     3.70           4.10           4.47            4.65           40.00
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INTER-LABORATORY STUDY     1076

POLLUTANT - CO                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  230         RANGE            23.74        C.I. (UPPER)   21.48
TRUE-VALUE       20.86         VARIANCE          3.92        C.I. (LOWER)   20.97
MEAN             21.23         STD. DEV.         1.98        SKEWNESS        4.16
MEDIAN           21.00         COEF. VAR.        9.32        ACCURACY         .67

DATA IN ASCENDING ORDER

10.80●  20.00   20.11   20.80   20.90   21.30   21.40   22.00   22.17   27.79
15.76   20.00   20.20   20.80   20.90   21.30   21.40   22.00   22.20   30.00●
16.19●  20.00   20.20   20.80   20.96   21.30   21.42   22.00   22.22   32.00
16.50   20.00   20.25   20.87   21.00   21.31   21.46   22.00   22.42   39.50
17.00●  20.00   20.25   20.90   21.00   21.31   21.49   22.10   22.50   40.05●
17.10   20.10   20.30   20.90   21.00   21.40   21.50   22.11   22.50
17.70●          20.30           21.00           21.50           22.50
18.00●          20.30           21.00           21.50           22.50
18.12           20.30           21.00           21.50           22.50
18.30           20.30           21.00           21.50           22.50
18.50           20.30           21.00           21.50           22.50
18.50●          20.34           21.00           21.50           22.50
18.60           20.39           21.00           21.50           22.50
18.60           20.40           21.00           21.50           22.50
18.60           20.40           21.00           21.50           22.52
18.66           20.40           21.00           21.50           22.55
18.75           [illegible]     21.00           21.50           22.60
18.75           20.47           21.00           21.50           22.65
19.00           20.50           21.00           21.50           22.70
19.00           20.50           21.00           21.50           22.80
19.00           20.50           21.00           21.50           22.90
19.10           20.50           21.00           21.50           23.00
19.30           20.50           21.00           21.50           23.00
19.42           20.50           21.00           21.50           23.00
19.50           20.60           21.00           21.50           23.00
19.50           20.60           21.00           21.53           23.00
19.50           20.60           21.00           21.60           23.00
19.53           20.61           21.00           21.65           23.16
19.57           20.65           21.02           21.65           23.20●
19.64           20.70           21.04           21.72           23.48●
19.70           20.70           21.10           21.75           23.48
19.70           20.70           21.10           21.80           23.48
19.72           20.70           21.10           21.86           23.50
19.75           20.74           21.20           21.90           24.00●
19.85           20.75           21.20           21.90           24.10
19.90           20.75           21.20           21.95           24.25●
19.90           20.75           21.20           22.00           24.38
19.90           20.75           21.20           22.00           24.50
20.00           20.75           21.20           22.00           24.50
20.00           20.80           21.20           22.00           24.56●
20.00           20.80           21.20           22.00           24.71●
20.00           20.80           21.25           22.00           26.60
20.00           20.80           21.30           22.00           27.20●
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INTER-LABORATORY STUDY    1076

POLLUTANT - CO                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 214          RANGE            16.39         C.I. (UPPER)    41.01
TRUE-VALUE      40.14          VARIANCE          4.30         C.I. (LOWER)    40.46
MEAN            40.73          STD. DEV.         2.07         SKEWNESS         1.76
MEDIAN          40.45          COEF. VAR.        5.09         ACCURACY          .78

DATA IN ASCENDING ORDER


      21.00● 39.10   39.20   40.00   40.00   40.80   40.98   42.00   42.09
      31.00● 39.10   39.24   40.00   40.00   40.87   40.99   42.00   42.12
      35.30● 39.10   39.26   40.00   40.00   40.90   41.00   42.00   42.26
      35.50●         39.30           40.05           41.00           42.38
      36.00●         39.40           40.07           41.00           42.50
      36.00●         39.50           40.10           41.00           42.52
      36.03●         39.50           40.10           41.00           42.61
      36.80          39.50           40.20           41.00           42.62
      37.20          39.50           40.20           41.00           42.66
      37.35          39.50           40.20           41.00           42.80
      37.50          39.50           40.20           41.00           42.81
      37.50          39.50           40.20           41.00           42.96
      37.50          39.50           40.25           41.00           43.00
      37.50          39.50           40.25           41.00           43.00
      37.50          39.50           40.30           41.00           43.00
      37.86          39.50           40.30           41.00           43.00
      37.90          39.50           40.30           41.13           43.00
      38.00          39.50           40.30           41.20           43.00
      38.00          39.50           40.40           41.25           43.20
      38.00          39.60           40.40           41.30           43.22
      38.02          39.60           40.40           41.30           43.46
      38.10          39.69           40.44           41.31           43.50
      38.20          39.70           40.47           41.40           43.50
      38.22          39.70           40.49           41.50           43.80
      38.30          39.70           40.50           41.50           43.95
      38.30          39.75           40.50           41.50           44.00
      38.50          39.75           40.50           41.50           44.35●
      38.50          39.80           40.50           41.50           44.50●
      38.54          39.80           40.50           41.50           44.50
      38.75          39.90           40.50           41.57           45.00
      38.80          39.91           40.50           41.60           45.00
      38.80          39.98           40.50           41.60           45.29
      38.90          40.00           40.50           41.60           45.70
      38.90          40.00           40.50           41.65           45.80●
      38.96          40.00           40.50           41.70           46.10
      39.00          40.00           40.50           41.75           46.39
      39.00          40.00           40.53           41.80           46.80●
      39.00          40.00           40.60           41.80           47.63●
      39.00          40.00           40.70           41.80           47.70
      39.00          40.00           40.75           41.84           47.75
      39.00          40.00           40.80           41.90           48.10●
      39.06          40.00           40.80           42.00           53.19
      39.10          40.00           40.80           42.00           80.00●
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INTER-LABORATORY STUDY 377

POLLUTANT - CO UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER - 1

N	279	RANGE	4.50	C.I. (UPPER)	3.15
TRUE-VALUE	3.38	VARIANCE	.36	C.I. (LOWER)	3.01
MEAN	3.08	STD. DEV.	.60	SKEWNESS	-.23
MEDIAN	3.04	COEF. VAR.	19.37	ACCURACY	-10.06

DATA IN ASCENDING ORDER

```
  .50    2.50   2.65   3.00   3.00   3.10   3.20   3.50   3.50   4.12
 1.00●   2.50   2.70   3.00   3.00   3.10   3.25   3.50   3.50   4.17
 1.50    2.50   2.70   3.00   3.00   3.15   3.25   3.50   3.50   4.30
 1.50    2.50   2.70   3.00   3.00   3.16   3.25   3.50   3.50   4.30
 1.52    2.50   2.70   3.00   3.00   3.17   3.25   3.50   3.50   4.35
 1.65●   2.50   2.70   3.00   3.00   3.18   3.25   3.50   3.50   4.50●
 1.74    2.50   2.70   3.00   3.00   3.20   3.25   3.50   3.50   4.50●
 1.75    2.50   2.75   3.00   3.00   3.20   3.25   3.50   3.52   4.50
 1.80    2.52   2.75   3.00   3.00   3.20   3.25   3.50   3.56   4.80
 1.80    2.56   2.75   3.00   3.00   3.20   3.25   3.50   3.58   5.00●
 1.84    2.60   2.77   3.00   3.00   3.20   3.25   3.50   3.60   5.00
 2.00    2.60   2.80   3.00   3.00   3.20   3.25   3.50   3.60   5.00
 2.00    2.60   2.80   3.00   3.00   3.20   3.25   3.50   3.65   8.80●
 2.00    2.60   2.80   3.00   3.00   3.20   3.25   3.50   3.70  27.39●
 2.00    2.61●  2.80   3.00   3.00   3.20   3.30   3.50   3.70  27.83●
 2.00    2.65   2.84   3.00   3.00   3.20   3.30   3.50   3.70
 2.00           2.86          3.00          3.30          3.75
 2.00           2.88          3.00          3.30          3.75
 2.00           2.89          3.00          3.30          3.80
 2.10           2.90          3.00          3.30          3.81
 2.10           2.90          3.00          3.30          3.90
 2.10           2.90          3.00          3.30          3.91
 2.11           2.90          3.00          3.30          3.91
 2.20           2.90          3.00          3.30          3.91
 2.24           2.90          3.04          3.30          3.91
 2.25           2.90          3.04          3.40          4.00●
 2.25           2.90          3.04          3.40          4.00●
 2.29           2.90          3.05          3.40          4.00●
 2.30           2.90          3.08          3.40          4.00●
 2.30           2.92          3.08          3.40          4.00
 2.30           2.95          3.08          3.40          4.00
 2.32           2.96          3.08          3.40          4.00
 2.33           2.96          3.10          3.40          4.00
 2.40●          2.98          3.10          3.45          4.00
 2.40           2.98          3.10          3.46          4.00
 2.40           2.99          3.10          3.47          4.00
 2.50           3.00          3.10          3.48          4.00
 2.50           3.00          3.10          3.50          4.00
 2.50           3.00          3.10          3.50          4.00
 2.50           3.00          3.10          3.50          4.00
 2.50           3.00          3.10          3.50          4.10●
 2.50           3.00          3.10          3.50          4.10
 2.50           3.00          3.10          3.50          4.10
```

INTER-LABORATORY STUDY 377

POLLUTANT - CO   UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER - 2

N	278	RANGE	20.00	C.I. (UPPER)	16.38
TRUE-VALUE	15.87	VARIANCE	2.28	C.I. (LOWER)	16.03
MEAN	16.20	STD. DEV.	1.51	SKEWNESS	4.41
MEDIAN	16.00	COEF. VAR.	9.31	ACCURACY	.82

DATA IN ASCENDING ORDER

3.04●
3.48●
8.85●
12.00
12.29
13.00●
13.10●
13.15
13.60
13.75
13.80
13.91●
14.00
14.00
14.00
14.00
14.07
14.34
14.38
14.40
14.50
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14.72
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14.86
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17.83
17.90
18.00●
18.00●
18.00●
18.10●
18.25
18.30●
18.50●
18.50
18.50

18.60
18.70
19.40
19.50●
19.84
20.00
20.26
21.00
21.50●
21.61
21.90●
29.50●
32.00
34.00●

INTER-LABORATORY STUDY 377

POLLUTANT - CO UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER - 3

N	275	RANGE	29.50	C.I. (UPPER)	32.73
TRUE-VALUE	31.72	VARIANCE	5.17	C.I. (LOWER)	32.19
MEAN	32.46	STD. DEV.	2.27	SKEWNESS	.09
MEDIAN	32.20	COEF. VAR.	7.00	ACCURACY	1.51

DATA IN ASCENDING ORDER

```
  3.55● 31.00  31.00  31.80  31.97  32.40  32.50  33.20  33.54  37.33
 13.48● 31.00  31.18  31.80  32.00  32.40  32.50  33.20  33.70  37.50
 13.48● 31.00  31.20  31.80  32.00  32.40  32.50  33.20  33.75  38.20●
 14.00  31.00  31.20  31.80  32.00  32.40  32.50  33.40  33.76  38.70
 15.00  31.00  31.20  31.80  32.00  32.49  32.50  33.40  33.80  39.68
 18.05● 31.00  31.20  31.80  32.00  32.50  32.50  33.40  33.80  39.79
 27.50● 31.00  31.25  31.81  32.00  32.50  32.50  33.41  33.88  40.50
 27.61● 31.00  31.27  31.85  32.00  32.50  32.59  33.50  33.90  41.00
 28.50● 31.00  31.30  31.90  32.00  32.50  32.60  33.50  33.91  42.00●
 28.50  31.00  31.30  31.90  32.00  32.50  32.60  33.50  34.00  43.49
 29.00  31.00  31.40  31.90  32.00  32.50  32.60  33.50  34.00  44.50
 29.00  31.00  31.40  31.90  32.00  32.50  32.61  33.50  34.00  69.00●
 29.50  31.00  31.40  31.90  32.00  32.50  32.61  33.50  34.00
 29.60  31.00  31.48  31.90  32.00  32.50  32.61  33.50  34.00
 29.90  31.00  31.50  31.90  32.00  32.50  32.67  33.50  34.00
 30.00  31.00  31.50  31.90  32.00  32.50  32.70  33.50  34.18
 30.00         31.50         32.00         32.70         34.20
 30.00         31.50         32.00         32.70         34.26
 30.00         31.50         32.00         32.75         34.31
 30.10         31.50         32.00         32.78         34.37
 30.10         31.50         32.00         32.80         34.50
 30.20         31.50         32.00         32.80         34.50
 30.20         31.50         32.00         32.80         34.50
 30.20         31.50         32.00         32.86         34.60
 30.25         31.50         32.10         32.90         34.60
 30.25         31.50         32.10         32.90         34.78
 30.40         31.50         32.20         32.94         34.78
 30.41         31.56         32.20         32.97         35.00●
 30.41         31.60         32.20         33.00         35.00●
 30.41         31.60         32.20         33.00         35.00
 30.50         31.60         32.20         33.00         35.00
 30.50         31.63         32.25         33.00         35.22
 30.50         31.70         32.25         33.00         35.25
 30.50         31.70         32.25         33.00         35.50●
 30.54         31.70         32.25         33.00         35.60
 30.54         31.70         32.25         33.00         36.00
 30.60         31.70         32.30         33.00         36.30●
 30.60         31.75         32.30         33.00         36.30
 30.60         31.75         32.30         33.00         36.40
 30.64         31.75         32.30         33.04         36.50●
 30.67         31.75         32.35         33.05         36.61
 30.80         31.78         32.40         33.09         37.00
 30.92         31.80         32.40         33.10         37.00
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INTER-LABORATORY STUDY      977

POLLUTANT - CO
                                        UNITS - MICROGRAMS PER CUBIC METER
SAMPLE NUMBER -  1

N                 243          RANGE           12.00          C.I. (UPPER)      4.72
TRUE-VALUE       4.79          VARIANCE          .88          C.I. (LOWER)      4.49
MEAN             4.60          STD. DEV.         .94          SKEWNESS          4.87
MEDIAN           4.50          COEF. VAR.      20.42          ACCURACY         -6.05

DATA IN ASCENDING ORDER


     2.50   4.00   4.10   4.40   4.50   4.59   4.70   5.00   5.00   6.00
     2.70   4.00   4.10   4.40   4.50   4.60   4.70   5.00   5.09   6.00
     2.80   4.00   4.10   4.40   4.50   4.60   4.70   5.00   5.10   6.00
     2.89   4.00   4.10   4.40   4.50   4.60   4.70   5.00   5.10   6.00
     2.90   4.00   4.10   4.40   4.50   4.60   4.70   5.00   5.10   6.30
     2.95   4.00   4.10   4.40   4.50   4.60   4.71   5.00   5.10   6.30
     3.00   4.00   4.10   4.40   4.50   4.60   4.71   5.00   5.10   6.50
     3.04   4.00   4.10   4.40   4.50   4.60   4.74   5.00   5.15   6.70
     3.20   4.00   4.10   4.40   4.50   4.69   4.75   5.00   5.15   6.70
     3.20   4.01   4.10   4.43   4.50   4.70   4.75   5.00   5.15   7.30
     3.20   4.01   4.11   4.44   4.50   4.70   4.78   5.00   5.20   8.30
     3.30●  4.01   4.12   4.44   4.50   4.70   4.80   5.00   5.20   9.3
     3.30   4.02   4.14   4.44   4.50   4.70   4.80   5.00   5.20  13.50
     3.40   4.07   4.15   4.44   4.50   4.70   4.80   5.00   5.20  14.50
     3.48   4.09   4.15   4.44   4.50   4.70   4.80   5.00   5.20
     3.50●         4.20          4.50          4.80          5.20
     3.50          4.20          4.50          4.80          5.22
     3.50          4.20          4.50          4.80          5.22
     3.50          4.20          4.50          4.80          5.25
     3.65          4.20          4.50          4.80          5.25
     3.66          4.20          4.50          4.80          5.25
     3.70●         4.20          4.50          4.80          5.27
     3.70          4.20          4.50          4.80          5.30
     3.73          4.25          4.50          4.81          5.43
     3.75          4.27          4.50          4.81          5.48●
     3.75●         4.30          4.50          4.82          5.50●
     3.80          4.30          4.50          4.83          5.50
     3.80          4.30          4.50          4.84          5.50
     3.80          4.30          4.50          4.87          5.50
     3.80          4.30          4.50          4.90          5.50
     3.80          4.30          4.50          4.90          5.50
     3.80          4.30          4.50          4.90          5.50
     3.80          4.30          4.50          4.92          5.50
     3.80          4.30          4.50          4.96          5.60
     3.88          4.30          4.50          5.00          5.60
     3.90          4.30          4.50          5.00          5.70
     3.90          4.30          4.50          5.00          5.70
     3.90          4.35          4.53          5.00          5.70
     3.96          4.35          4.55          5.00          5.80
     4.00          4.35          4.55          5.00          5.90
     4.00          4.35          4.55          5.00          5.90
     4.00          4.39          4.56          5.00          6.00
     4.00          4.40          4.59          5.00          6.00
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INTER-LABORATORY STUDY      977

POLLUTANT - CO                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N               244          RANGE           9.30         C.I. (UPPER)    16.84
TRUE-VALUE    16.59          VARIANCE        1.07         C.I. (LOWER)    16.58
MEAN          16.71          STD. DEV.       1.04         SKEWNESS         -.17
MEDIAN        16.68          COEF. VAR.      6.20         ACCURACY          .57

DATA IN ASCENDING ORDER


     11.70  15.80   16.00  16.38   16.50  16.80   16.99  17.44   17.50  19.00
     13.50  15.80   16.00  16.40   16.50  16.80   17.00  17.44   17.50  19.00
     13.70  15.86   16.00  16.40   16.50  16.80   17.00  17.45   17.50  19.13
     13.90● 15.89   16.00  16.40   16.50  16.80   17.00  17.50   17.50  19.42
     14.00● 15.99   16.00  16.40   16.50  16.80   17.00  17.50   17.50  19.50
     14.20  15.99   16.00  16.41   16.50  16.80   17.00  17.50   17.50  20.00●
     14.50● 16.00   16.00  16.47   16.50  16.82   17.00  17.50   17.50  20.30●
     14.75  16.00   16.00  16.47   16.50  16.82   17.00  17.50   17.58  21.00●
     14.78  16.00   16.00  16.50   16.50  16.85   17.00  17.50   17.60  21.00
     14.80  16.00   16.09  16.50   16.50  16.90   17.00  17.50   17.70  21.65●
     14.90  16.00   16.10  16.50   16.50  16.90   17.00  17.50   17.70  21.66
     14.90  16.00   16.10  16.50   16.50  16.90   17.00  17.50   17.70  21.89
     14.90  16.00   16.10  16.50   16.50  16.90   17.00  17.50   17.80  22.89
     14.90  16.00   16.10  16.50   16.50  16.90   17.00  17.50   17.80  24.00
     14.90  16.00   16.13  16.50   16.50  16.90   17.00  17.50   17.80
     15.00          16.16          16.55          17.00          17.80
     15.00          16.17          16.55          17.00          17.80
     15.05          16.20          16.60          17.00          17.89
     15.06          16.20          16.60          17.00          17.90
     15.06          16.20          16.60          17.04          17.90
     15.10          16.20          16.60          17.08          17.90
     15.20          16.20          16.60          17.10          18.00
     15.20          16.20          16.60          17.10          18.00
     15.40          16.20          16.60          17.10          18.00
     15.49          16.20          16.62          17.11          18.00
     15.50          16.20          16.65          17.20          18.00
     15.50          16.25          16.67          17.20          18.00
     15.50          16.27          16.68          17.20          18.00
     15.50          16.30          16.69          17.20          18.04
     15.50          16.30          16.70          17.30          18.10
     15.50          16.30          16.70          17.30          18.10
     15.50          16.30          16.70          17.30          18.20
     15.56          16.30          16.70          17.30          18.25
     15.60          16.30          16.70          17.30          18.26
     15.60          16.30          16.70          17.30          18.38●
     15.64          16.30          16.73          17.30          18.40
     15.70          16.30          16.73          17.30          18.50
     15.70          16.30          16.74          17.30          18.50
     15.70          16.30          16.75          17.30          18.50
     15.75          16.30          16.75          17.30          18.50
     15.80          16.30          16.76          17.30          18.60
     15.80          16.38          16.77          17.39          18.70
     15.80          16.38          16.80          17.40          18.90
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INTER-LABORATORY STUDY      977

POLLUTANT - CO                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   3

N                  244          RANGE             13.20          C.I. (UPPER)      36.90
TRUE-VALUE       36.00          VARIANCE           3.00          C.I. (LOWER)      36.46
MEAN             36.68          STD. DEV.          1.73          SKEWNESS           1.07
MEDIAN           36.40          COEF. VAR.         4.72          ACCURACY           1.12

DATA IN ASCENDING ORDER


    29.00●  35.30   35.50   36.00   36.20   36.50   36.70   37.50   38.00   42.00●
    30.80   35.32   35.57   36.00   36.20   36.51   36.70   37.50   38.00   43.00●
    31.40●  35.40   35.58   36.00   36.20   36.51   36.80   37.50   38.00   43.20●
    32.10●  35.40   35.60   36.00   36.20   36.60   36.90   37.50   38.00   43.25
    32.17   35.41   35.60   36.00   36.20   36.60   36.90   37.50   38.00   43.48
    32.30   35.45   35.60   36.00   36.22   36.60   36.90   37.50   38.02   43.50
    33.10   35.50   35.60   36.09   36.24   36.60   36.95   37.60   38.10   44.00
    33.30   35.50   35.68   36.10   36.25   36.60   36.96   37.60   38.20   44.00
    33.50   35.50   35.68   36.10   36.25   36.62   37.00   37.70   38.20   44.09
    33.90   35.50   35.70   36.10   36.25   36.66   37.00   37.70   38.21   45.89
    34.00   35.50   35.80   36.10   36.25   36.70   37.00   37.80   38.40   51.22
    34.20   35.50   35.80   36.10   36.25   36.70   37.00   37.80   38.40
    34.30   35.50   35.80   36.10   36.28   36.70   37.00   38.00   38.40
    34.50   35.50   35.80   36.12   36.30   36.70   37.00   38.00   38.50
    34.50   35.50   35.80   36.17   36.30   36.70   37.00   38.00   38.50
    34.50   35.50   35.80   36.20   36.30   36.70   37.00   38.00   38.50
    34.50           35.82           36.30           37.00           38.60
    34.50           35.82           36.30           37.00           38.70
    34.60           35.83           36.31           37.00           38.80
    34.60           35.85           36.31           37.00           38.80
    34.62           35.90           36.36           37.00           39.00
    34.65           35.90           36.38           37.00           39.00
    34.70           35.90           36.40           37.00           39.00
    34.90           35.90           36.40           37.00           39.00
    34.90           35.90           36.40           37.00           39.00
    34.95           35.90           36.41           37.00           39.10
    35.00           35.90           36.45           37.10           39.10
    35.00           35.91           36.45           37.10           39.13
    35.00           35.91           36.50           37.20           39.30
    35.00           35.92           36.50           37.20           39.30
    35.00           35.95           36.50           37.20           39.44
    35.00           35.99           36.50           37.20           39.44
    35.00           35.99           36.50           37.20           39.50
    35.01           36.00           36.50           37.39           39.50
    35.10           36.00           36.50           37.40           39.80●
    35.10           36.00           36.50           37.40           40.00
    35.20           36.00           36.50           37.40           40.00
    35.20           36.00           36.50           37.50           40.00
    35.20           36.00           36.50           37.50           40.00
    35.20           36.00           36.50           37.50           40.50
    35.25           36.00           36.50           37.50           40.90●
    35.29           36.00           36.50           37.50           41.00
    35.30           36.00           36.50           37.50           41.55
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INTER-LABORATORY STUDY    1076

POLLUTANT - SO4                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   94      RANGE            7.81       C.I.(UPPER)    2.25
TRUE-VALUE        1.22      VARIANCE         2.05       C.I.(LOWE  R)    1.68
MEAN              1.96      STD. DEV.        1.43       SKEWNESS       1.84
MEDIAN            1.65      COEF. VAR.      72.85       ACCURACY      34.91

DATA IN ASCENDING ORDER

        .09            1.00            1.51            1.96            3.30
        .09            1.00            1.51            2.02            3.30
        .33●           1.01            1.56            2.22●           3.74
        .33●           1.01            1.56            2.23            3.75
        .39            1.05            1.62            2.29            3.76
        .40            1.10            1.64●           2.40            4.35
        .40            1.15            1.68            2.40            4.44
        .40            1.17            1.70            2.40            4.69
        .53            1.19            1.70            2.40            4.78
        .60            1.20            1.75            2.40            5.40
        .60            1.22            1.77            2.40            5.47
        .60            1.23            1.77            2.45            6.42●
        .60            1.24            1.80            2.46●           6.46●
        .70            1.28            1.80            2.50            6.96●
        .80            1.29            1.80            2.50            7.61
        .80            1.30            1.80            2.70            7.90
        .80            1.30            1.80            2.70●           7.95●
        .83            1.35            1.82●           2.74            9.36●
        .90            1.45            1.90            2.90           11.00●
        .96            1.50            1.92            3.00           11.10●
        .96            1.50            1.92            3.00
        .99            1.50            1.95            3.20
```

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INTER-LABORATORY STUDY    1076

POLLUTANT - SO4                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                39          RANGE           5.76         C.I.(UPPER)   1.64
TRUE-VALUE      .00          VARIANCE        1.58         C.I.(LOWE  R)     .85
MEAN           1.24          STD. DEV.       1.26         SKEWNESS       1.51
MEDIAN          .90          COEF. VAR.    101.17         ACCURACY        .00
DATA IN ASCENDING ORDER

          .04            .30            .90           1.75           3.68
          .05            .30            .96           1.82●          4.80●
          .06            .40            .98           1.84           5.80
          .11            .42           1.20           2.40           6.49●
          .12            .42           1.30           2.40          11.10●
          .16            .60           1.49           2.50
          .19            .60           1.50           2.85
          .24            .80           1.62●          3.20
          .25            .80           1.68           3.21
          .27            .90           1.73           3.63●
```

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INTER-LABORATORY STUDY     1076

POLLUTANT - SO4                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   4

N                  48        RANGE            6.93          C.I.(UPPER)    3.64
TRUE-VALUE       3.01        VARIANCE         1.75          C.I.(LOWE  R)    2.89
MEAN             3.26        STD. DEV.        1.32          SKEWNESS         .84
MEDIAN           3.10        COEF. VAR.      40.62          ACCURACY        3.09

DATA IN ASCENDING ORDER

        .09             2.56             3.10             3.45             5.80
        .60●            2.61             3.10             3.48             6.30
       1.30             2.67             3.11             3.50             6.90
       1.44             2.70             3.12             3.66●            7.02
       1.44             2.86             3.18             3.95             8.69●
       1.44             2.88             3.18             4.05             8.88●
       1.89●            2.90             3.21             4.08             9.00●
       2.14             2.91             3.25             4.10
       2.24             3.00             3.30             4.38●
       2.40             3.00             3.30             4.44
       2.40             3.00             3.30             4.50
       2.45             3.00             3.36             5.00
```

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INTER-LABORATORY STUDY     1076

POLLUTANT - SO4                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  8

N                 99        RANGE           14.01         C.I.(UPPER)  10.47
TRUE-VALUE     10.22        VARIANCE         2.61         C.I.(LOWE  R)   9.83
MEAN           10.15        STD. DEV.        1.62         SKEWNESS        -.49
MEDIAN         10.10        COEF. VAR.      15.93         ACCURACY       -1.16

DATA IN ASCENDING ORDER


        1.80           9.15           9.81          10.50          11.55
        2.19●          9.20           9.83          10.50          11.64
        2.25●          9.24           9.84          10.53          11.70
        3.85●          9.30          10.00          10.60          11.82
        5.54●          9.30          10.08          10.60          12.10●
        7.50           9.30          10.10          10.60          12.12●
        7.52           9.33          10.10          10.62          12.12
        7.52           9.38          10.10          10.63          12.60
        7.68           9.40          10.19          10.65          12.60
        8.58           9.40          10.20          10.65          12.72●
        8.70           9.45          10.20          10.70          13.00●
        8.70           9.50          10.20          10.70          13.33
        8.70           9.59          10.21          10.93          14.10
        8.89           9.60          10.33          11.00          14.40●
        9.00           9.64          10.37          11.03          15.12●
        9.00           9.66          10.38          11.23          15.30
        9.00           9.69          10.38          11.25          15.81
        9.00           9.70          10.39          11.25          17.64●
        9.06           9.75          10.40          11.49          18.63●
        9.10           9.75          10.40          11.50          20.00●
        9.12           9.79          10.42          11.52          20.90●
        9.12           9.80          10.49          11.52
        9.15           9.80          10.50          11.52
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INTER-LABORATORY STUDY     277

POLLUTANT - SO4                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  C

N                 110       RANGE          58.24        C.I.(UPPER)  22.36
TRUE-VALUE      21.16       VARIANCE       29.69        C.I.(LOWE  R)  20.33
MEAN            21.34       STD. DEV.       5.45        SKEWNESS       7.30
MEDIAN          21.10       COEF. VAR.     25.53        ACCURACY       -.28

DATA IN ASCENDING ORDER


     13.96           19.62           20.51           21.72           22.75
     14.46           19.65           20.60           21.75           22.86
     15.00           19.75           20.70           21.80           22.90
     15.40●          19.76           20.74           21.90           23.02
     15.45           19.76           20.76           21.90           23.02
     15.50●          19.80           20.79           21.90           23.20
     15.66           19.80           20.81           21.90           23.30
     15.77           19.80           21.00           21.90           23.40
     15.81           19.88           21.00           22.00           23.76
     16.32           19.88           21.00           22.00           23.90
     16.95           19.92           21.10           22.00           24.00
     17.20           19.95           21.10           22.00           24.34
     17.20           19.95           21.14           22.05           24.48
     17.43           20.00           21.16           22.05           24.48
     17.90           20.10           21.20           22.15           25.30
     18.70           20.15           21.20           22.20           25.44
     18.90           20.18           21.20           22.50           25.56
     19.04           20.40           21.21           22.50           25.90
     19.26           20.40           21.36           22.50           27.00
     19.50           20.40           21.40           22.50           31.80●
     19.50           20.40           21.43           22.50           38.10●
     19.50           20.48           21.48           22.56           72.20
     19.50           20.50           21.70           22.56
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INTER-LABORATORY STUDY     277

POLLUTANT - SO4                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N               107        RANGE          51.12        C.I.(UPPER)  17.26
TRUE-VALUE    15.63        VARIANCE       31.19        C.I.(LOWER)  15.14
MEAN          16.20        STD. DEV.       5.58        SKEWNESS      4.54
MEDIAN        15.90        COEF. VAR.     34.48        ACCURACY      1.73

DATA IN ASCENDING ORDER


         1.14         14.34         15.56         16.30         17.28
         4.95         14.40         15.59         16.30         17.30
         9.00         14.40         15.64         16.30         17.30
        10.80●        14.40         15.75         16.32         17.49
        11.14         14.40         15.80         16.35         17.52
        11.14         14.46         15.83         16.35         17.59
        11.40●        14.70         15.89         16.40         17.85
        11.40         14.79         15.90         16.50         18.00
        13.05         14.85         15.90         16.50         18.00
        13.08         14.90         15.90         16.50         19.34
        13.24         15.00         15.90         16.50         19.34
        13.35         15.00         16.00         16.50         19.43
        13.35         15.00         16.02         16.66         19.44
        13.44         15.06         16.04         16.72         20.99
        13.50         15.07         16.07         16.80         24.57
        13.50         15.10         16.10         16.80         28.50●
        13.60         15.12         16.15         16.98         29.40●
        13.80         15.27         16.17         17.10         51.17
        14.00         15.30         16.20         17.20         52.26
        14.00         15.36         16.20         17.21
        14.10         15.45         16.20         17.28
        14.30         15.50         16.23         17.28
        14.32         15.55         16.25         17.28
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INTER-LABORATORY STUDY      277

POLLUTANT - SO4                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                  56        RANGE          23.18        C.I.(UPPER)   25.19
TRUE-VALUE      24.87        VARIANCE       12.88        C.I.(LOWE  R)  23.31
MEAN            24.25        STD. DEV.       3.59        SKEWNESS        -.37
MEDIAN          24.41        COEF. VAR.     14.80        ACCURACY       -1.83

DATA IN ASCENDING ORDER

      12.82          23.21          24.30          25.10          26.00
      14.80          23.27          24.30          25.10          26.40
      15.69          23.40          24.30          25.20          26.40
      17.10          23.48          24.32          25.20          26.70
      20.10          23.52          24.38          25.30          27.60
      20.82          23.60          24.45          25.43          28.70
      21.70          24.00          24.50          25.44          30.46
      21.90          24.00          24.51          25.51          32.10
      21.90          24.00          24.60          25.80          36.00
      22.20          24.00          24.75          25.86          46.20
      22.70          24.20          25.01          25.92
      23.02          24.25          25.10          25.95
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INTER-LABORATORY STUDY     277

POLLUTANT - SO4                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  9

N                   53        RANGE           41.64        C.I.(UPPER)    7.86
TRUE-VALUE        4.47        VARIANCE        40.87        C.I.(LOWE  R)    4.42
MEAN              6.14        STD. DEV.        6.39        SKEWNESS        4.06
MEDIAN            4.62        COEF. VAR.     104.11        ACCURACY        3.36

DATA IN ASCENDING ORDER


         .32             4.10             4.60             5.20             6.47
        1.02             4.11             4.60             5.29             8.70●
        2.06             4.20             4.60             5.30            10.08
        3.00             4.20             4.62             5.37            11.40
        3.05             4.20             4.63             5.40            20.97
        3.10             4.30             4.80             5.43            25.64
        3.30●            4.40             4.80             5.55            41.96
        3.35             4.50             4.86             5.62
        3.75             4.50             4.95             5.68
        3.90             4.50             4.98             6.00
        3.98             4.57             5.04             6.24
        4.06             4.60             5.18             6.40
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INTER-LABORATORY STUDY     877

POLLUTANT - SO4                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 40        RANGE           4.96        C.I.(UPPER)    1.32
TRUE-VALUE       .00        VARIANCE        1.12        C.I.(LOWE  R)    .66
MEAN             .99        STD. DEV.       1.06        SKEWNESS       1.81
MEDIAN           .60        COEF. VAR.    105.75        ACCURACY        .00

DATA IN ASCENDING ORDER


        .09             .25             .55            1.00           1.88
        .14             .25             .60            1.08           2.16
        .15             .28             .60            1.20           2.34
        .18             .30             .60            1.20           2.40
        .18             .30             .64            1.40           3.00
        .18             .30             .73            1.44           3.10
        .20             .30             .80            1.50           3.12
        .21             .48             .90            1.72           5.05
        .24             .50             .99            1.82
```

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INTER-LABORATORY STUDY      877

POLLUTANT - SO4                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 59        RANGE           14.20         C.I.(UPPER)  11.24
TRUE-VALUE     11.10        VARIANCE         3.66         C.I.(LOWE  R)  10.27
MEAN           10.76        STD. DEV.        1.91         SKEWNESS         .98
MEDIAN         10.83        COEF. VAR.      17.78         ACCURACY       -2.43

DATA IN ASCENDING ORDER


       .51●          9.67          10.50          11.10          11.88
      2.40●          9.80          10.70          11.18          12.00
      5.30           9.82          10.70          11.19          12.23
      5.76           9.84          10.79          11.25          12.36
      6.90●          9.90          10.79          11.28          12.90
      7.55           9.90          10.80          11.34          12.96●
      7.80           9.99          10.83          11.40          13.51
      8.58●         10.00          10.87          11.40          14.55
      9.00          10.02          11.00          11.60          19.50
      9.00          10.09          11.00          11.69
      9.55          10.09          11.03          11.71
      9.60          10.10          11.04          11.80
      9.60          10.14          11.06          11.80
      9.60          10.35          11.10          11.88
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INTER-LABORATORY STUDY      877

POLLUTANT - SO4                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  60     RANGE          181.02        C.I.(UPPER)  21.31
TRUE-VALUE      13.50     VARIANCE       492.95        C.I.(LOWE  R)  10.08
MEAN            15.70     STD. DEV.       22.20        SKEWNESS      7.20
MEDIAN          13.26     COEF. VAR.     141.45        ACCURACY     -1.74

DATA IN ASCENDING ORDER


        .63●        12.00        12.82        13.59        14.90
       2.58         12.00        12.84        13.68        15.00
       2.70         12.06        12.92        13.70        15.00
       2.82●        12.19        12.92        13.80        15.06
       6.90●        12.30        13.10        13.80        15.43
       7.50         12.30        13.15        13.80        15.84●
       9.06         12.38        13.20        13.80        15.91
      10.14●        12.45        13.33        13.95        15.98
      10.20         12.60        13.33        14.00        21.30
      10.20         12.60        13.34        14.00       183.60
      11.00         12.60        13.38        14.11
      11.16         12.62        13.48        14.41
      11.84         12.71        13.49        14.46
      11.90         12.78        13.50        14.55
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INTER-LABORATORY STUDY     877

POLLUTANT - SO4                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  6

N                  58        RANGE           17.90         C.I.(UPPER)  16.59
TRUE-VALUE      15.20        VARIANCE         6.99         C.I.(LOWE  R)  15.23
MEAN            15.91        STD. DEV.        2.64         SKEWNESS       2.18
MEDIAN          15.45        COEF. VAR.      16.61         ACCURACY      -4.60

DATA IN ASCENDING ORDER

        .78●         14.20          15.15          15.80          16.80
       3.22●         14.55          15.18          15.90          17.59
       9.00●         14.82          15.24          15.94          17.60
      10.00          14.90          15.30          16.00          17.62
      12.00          14.97          15.30          16.06          17.73
      12.30          15.00          15.34          16.12          18.00
      12.48●         15.01          15.36          16.20          18.24
      12.77          15.02          15.42          16.20          18.54
      13.50          15.06          15.49          16.23          20.97
      13.80          15.10          15.57          16.35          24.48●
      14.00          15.12          15.72          16.43          25.30
      14.09          15.12          15.74          16.50          27.90
      14.15          15.14          15.77          16.68
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INTER-LABORATORY STUDY      877

POLLUTANT - SO4                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                  58      RANGE          6.40        C.I.(UPPER)    3.35
TRUE-VALUE       3.00      VARIANCE       1.60        C.I.(LOWE  R)    2.70
MEAN             3.02      STD. DEV.      1.27        SKEWNESS        .18
MEDIAN           3.04      COEF. VAR.    41.86        ACCURACY       1.50

DATA IN ASCENDING ORDER


          .18●          2.02          2.95          3.20          3.84
          .20           2.25          2.96          3.21          4.00
          .30           2.34          3.00          3.24          4.10
          .54●          2.60          3.00          3.27          4.20
          .54           2.68          3.00          3.30          4.37●
          .64           2.70          3.02          3.30          4.44
          .79           2.70          3.03          3.36          5.05
          .90●          2.73          3.06          3.36          5.18
         1.05           2.73          3.12          3.39          5.82
         1.68           2.75          3.12          3.60          6.00
         1.80           2.81          3.14          3.70          6.60
         1.98           2.90          3.15          3.70          7.20●
         2.00           2.93          3.16          3.76
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INTER-LABORATORY STUDY      877

POLLUTANT - SO4                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  8

N                   55        RANGE          6.37         C.I.(UPPER)    2.81
TRUE-VALUE        2.10        VARIANCE       1.38         C.I.(LOWE  R)    2.19
MEAN              2.50        STD. DEV.      1.18         SKEWNESS       1.07
MEDIAN            2.30        COEF. VAR.    47.09         ACCURACY       9.52

DATA IN ASCENDING ORDER

                                                                           /
          .04           1.89           2.28           2.55           3.59●
          .15●          1.92           2.28           2.60           3.84
          .42●          1.97           2.30           2.60           4.32●
          .43           1.98           2.30           2.70           4.68
          .50           2.00           2.40           2.70           4.70
          .60           2.00           2.40           2.88           5.05
         1.30           2.00           2.40           2.94           5.86
         1.40           2.04           2.40           3.00           6.41
         1.58           2.16           2.40           3.10
         1.71           2.18           2.40           3.16
         1.76           2.22           2.50           3.21
         1.80           2.23           2.55           3.40
         1.80           2.26           2.55           3.50
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INTER-LABORATORY STUDY    1075

POLLUTANT - NO3                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                  72        RANGE            1.51        C.I.(UPPER)     .71
TRUE-VALUE        .54        VARIANCE          .07        C.I.(LOWE  R)     .59
MEAN              .65        STD. DEV.         .27        SKEWNESS         .36
MEDIAN            .64        COEF. VAR.      41.06        ACCURACY       18.52

DATA IN ASCENDING ORDER


         .10●          .49          .60          .72          .95
         .13           .50          .60          .75          .96
         .13           .50          .60          .76          .98
         .14           .50          .60          .78          .99
         .14           .50          .61          .80         1.00
         .15           .51          .64          .80         1.02
         .17           .55          .64          .80         1.04
         .18           .55          .64          .81         1.05
         .24●          .56          .64          .81         1.10
         .30           .57          .64          .83         1.64
         .40           .57          .66          .83         4.32●
         .40           .58          .66          .84         4.32●
         .40           .58          .66          .87         6.11●
         .45           .59          .69          .87         7.04●
         .45           .59          .70          .90
         .48           .60          .71          .90
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INTER-LABORATORY STUDY    1076

POLLUTANT - NO3                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 30        RANGE              .46        C.I.(UPPER)     .29
TRUE-VALUE       .00        VARIANCE           .03        C.I.(LOWE  R)    .17
MEAN             .23        STD. DEV.          .16        SKEWNESS       -.02
MEDIAN           .26        COEF. VAR.       70.11        ACCURACY        .00

DATA IN ASCENDING ORDER


       .01           .07           .25           .34           .45
       .01           .10           .27           .38           .47
       .01           .10           .28           .40          1.40●
       .02           .10           .30           .42          3.41●
       .02           .11           .33           .42          3.67●
       .06           .18           .33           .44
       .07           .19           .34           .45
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INTER-LABORATORY STUDY     1076

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 37       RANGE          11.50        C.I.(UPPER)    8.22
TRUE-VALUE      9.42       VARIANCE       10.79        C.I.(LOWE  R)    5.10
MEAN            7.16       STD. DEV.       3.28        SKEWNESS        -.80
MEDIAN          8.40       COEF. VAR.     45.89        ACCURACY      -10.82

DATA IN ASCENDING ORDER

         .20          4.56          8.28          9.47         11.37
         .22●         5.07          8.40          9.56         11.70
         .28          6.00          8.40          9.57         13.90●
        1.80          6.26          8.90          9.60         27.23●
        1.95          6.60          9.13          9.65
        2.02          7.35          9.25          9.70
        2.15          7.90          9.27          9.80
        2.22          8.10          9.30         10.00
        3.12          8.20          9.38         10.30
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INTER-LABORATORY STUDY     1076

POLLUTANT - NO3                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  8

N                 74        RANGE           8.07         C.I.(UPPER)    3.51
TRUE-VALUE      3.39        VARIANCE        2.26         C.I.(LOWE  R)    2.93
MEAN            3.27        STD. DEV.       1.50         SKEWNESS       1.05
MEDIAN          3.45        COEF. VAR.     46.01         ACCURACY       1.83

DATA IN ASCENDING ORDER


         .57          2.70          3.40          3.58          4.20
         .57          2.70          3.42          3.59          4.27
         .75          3.18          3.45          3.60          4.32
         .77          3.19          3.45          3.61          4.34
         .80          3.20          3.45          3.63          5.19
         .81          3.20          3.46          3.63          7.28●
         .81          3.20          3.48          3.65          7.28●
         .82          3.20          3.48          3.72          8.30
        1.04          3.20          3.48          3.72          8.40
        1.05          3.20          3.50          3.74          8.64
        1.40●         3.24          3.50          3.80         11.35●
        1.56          3.26          3.50          3.90         13.42●
        1.62          3.30          3.51          3.97
        2.19          3.33          3.54          4.01
        2.22          3.34          3.55          4.08
        2.22          3.40          3.55          4.18●
        2.60          3.40          3.56          4.20
```

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INTER-LABORATORY STUDY      277

POLLUTANT - NO3                              UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  C

N                 76          RANGE            9.75         C.I.(UPPER)  11.02
TRUE-VALUE     10.92          VARIANCE         2.41         C.I.(LOWE  R)  10.32
MEAN           10.67          STD. DEV.        1.55         SKEWNESS        -.60
MEDIAN         11.00          COEF. VAR.      14.55         ACCURACY         .73

DATA IN ASCENDING ORDER


       .74●          9.57          10.78          11.20          12.00
       .83●          9.60          10.80          11.21          12.07
      2.13●          9.60          10.80          11.21          12.07
      2.25●          9.72          10.80          11.22          12.36
      2.52●          9.82          10.84          11.23          12.75
      2.52●         10.02          10.94          11.30          12.82
      2.52●         10.22          10.98          11.31          13.18
      2.55●         10.22          10.98          11.35          15.95
      6.20          10.30          11.02          11.42          17.16●
      6.50          10.31          11.09          11.50          19.80●
      7.02          10.40          11.10          11.51          99.00●
      7.05          10.40          11.10          11.59         122.79●
      7.14          10.50          11.10          11.60         133.00●
      7.44          10.58          11.13          11.61         173.03●
      7.74          10.60          11.15          11.70
      8.65          10.61          11.15          11.78
      9.04          10.69          11.17          11.89
      9.12          10.70          11.17          11.98
      9.26          10.74          11.20          12.00
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INTER-LABORATORY STUDY      277

POLLUTANT - NO3                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  76         RANGE            4.04        C.I.(UPPER)    5.44
TRUE-VALUE       5.17         VARIANCE          .54        C.I.(LOWE  R)    5.11
MEAN             5.27         STD. DEV.         .73        SKEWNESS        .44
MEDIAN           5.30         COEF. VAR.      13.89        ACCURACY       2.51

DATA IN ASCENDING ORDER

         .54 ●          4.60            5.18            5.45            6.10
         .71●           4.63            5.18            5.47            6.11
        1.17●           4.70            5.20            5.50            6.20
        1.22 ●          4.80            5.20            5.53            6.36
        1.29●           4.80            5.24            5.53            6.60
        1.29●           4.80            5.25            5.55            6.67
        1.32●           4.96            5.27            5.55            7.46
        1.34 ●          5.02            5.30●           5.55            7.74
        3.70            5.05            5.30            5.56            9.79
        3.78            5.07            5.30            5.60           11.34
        3.78            5.10            5.30            5.63           40.93●
        3.93            5.10            5.30            5.64           56.00●
        4.05            5.10            5.37            5.66           57.07●
        4.11            5.10            5.38            5.68          132.00●
        4.20            5.10            5.39            5.79
        4.20            5.12            5.40 ●          5.85
        4.25            5.13            5.40            5.85
        4.25            5.15            5.42            5.86
        4.54            5.17            5.45            6.10
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INTER-LABORATORY STUDY      277

POLLUTANT - NO3                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                 40       RANGE            2.20         C.I.(UPPER)   2.40
TRUE-VALUE      1.94       VARIANCE          .19         C.I.(LOWE  R)   2.13
MEAN            2.27       STD. DEV.         .43         SKEWNESS       1.57
MEDIAN          2.21       COEF. VAR.      19.08         ACCURACY      13.92

DATA IN ASCENDING ORDER


         .15●         1.90          2.10          2.34          2.80
         .50●         1.91          2.10          2.34          2.86
         .57●         1.92          2.12          2.39          3.36
         .60          1.94          2.20          2.42          3.97
        1.67          2.00          2.22          2.50          6.07●
        1.72          2.00          2.25          2.50         18.98●
        1.73          2.00          2.25          2.56         22.00●
        1.89          2.05          2.30          2.50
        1.90          2.07          2.30          2.61
        1.90          2.07          2.31          2.54
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INTER-LABORATORY STUDY      277

POLLUTANT - NO3                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  9

N                 38        RANGE           4.32        C.I.(UPPER)   7.55
TRUE-VALUE      7.39        VARIANCE         .91        C.I.(LOWE  R)   6.94
MEAN            7.24        STD. DEV.        .95        SKEWNESS       -.77
MEDIAN          7.39        COEF. VAR.     13.17        ACCURACY        .20

DATA IN ASCENDING ORDER


       .55●         6.38          7.21          7.81          8.56
      1.68●         6.43          7.36          7.89          8.99
      1.74●         6.70          7.39          7.90         11.10●
      1.77●         6.75          7.40          7.95         65.49●
      4.56          6.80          7.45          7.96         81.00●
      5.10          6.87          7.59          8.00
      5.64          7.00          7.61          8.10
      5.78          7.02          7.65          8.17
      6.15          7.20          7.66          8.38
      6.38          7.20          7.70          8.51
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INTER-LABORATORY STUDY      877

POLLUTANT - NO3                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                  38        RANGE            4.94       C.I.(UPPER)     .62
TRUE-VALUE        .00        VARIANCE          .65       C.I.(LOWE  R)     .11
MEAN              .37        STD. DEV.         .81       SKEWNESS       4.88
MEDIAN            .19        COEF. VAR.     219.02       ACCURACY        .00

DATA IN ASCENDING ORDER


       .02            .07            .15            .32            .72
       .02            .08            .19            .34           1.30
       .02            .08            .19            .40           4.96
       .03            .08            .20            .40          21.30●
       .03            .09            .20            .42
       .04            .09            .20            .45
       .05            .10            .24            .46
       .06            .10            .25            .50
       .06            .14            .30            .71
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INTER-LABORATORY STUDY      877

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 44          RANGE           9.80        C.I.(UPPER)    5.88
TRUE-VALUE      6.00          VARIANCE        3.58        C.I.(LOWE  R)    4.76
MEAN            5.32          STD. DEV.       1.89        SKEWNESS      -1.07
MEDIAN          5.78          COEF. VAR.     35.57        ACCURACY      -3.58

DATA IN ASCENDING ORDER

        .50              4.67●              5.74              6.00              6.24
        .55              4.90               5.75              6.01              6.59
        .60              5.10               5.77              6.02              6.60
       1.31              5.28               5.77              6.08              6.76
       1.32              5.45               5.78              6.08              7.00
       1.35●             5.46               5.79              6.10              7.12
       1.40●             5.49               5.82              6.10             10.30
       3.46              5.58               5.84              6.12             20.30●
       3.54              5.70               5.91              6.19
       4.42              5.73               5.95              6.19
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INTER-LABORATORY STUDY     877

POLLUTANT - NO3                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   5

N                  44        RANGE             5.67         C.I.(UPPER)    4.47
TRUE-VALUE       4.80        VARIANCE          2.50         C.I.(LOWE  R)    3.53
MEAN             4.00        STD. DEV.         1.58         SKEWNESS      -1.40
MEDIAN           4.65        COEF. VAR.       39.55         ACCURACY      -3.13

DATA IN ASCENDING ORDER


          .10              2.66             4.54             4.78             5.04
          .25              3.00             4.60             4.80             5.06
          .38              3.74●            4.63             4.89             5.09
          .47              3.75             4.64             4.90             5.10
         1.09              4.10             4.65             4.93             5.15
         1.15●             4.38             4.65             4.94             5.61
         1.15●             4.39             4.68             4.94             5.77
         1.19              4.48             4.68             4.99            24.00●
         1.52              4.51             4.70             5.00
         2.64              4.53             4.72             5.04
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INTER-LABORATORY STUDY      877

POLLUTANT - NO3                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  6

N                  44         RANGE           8.65        C.I.(UPPER)    7.12
TRUE-VALUE       7.80         VARIANCE        4.85        C.I.(LOWE  R)    5.82
MEAN             6.47         STD. DEV.       2.20        SKEWNESS      -1.65
MEDIAN           7.34         COEF. VAR.     34.01        ACCURACY      -5.90

DATA IN ASCENDING ORDER


          .54            5.70●          7.23           7.55           7.95
          .55            5.80           7.24           7.59           7.96
          .78            6.40           7.30           7.68           7.97
         1.68            6.42           7.31           7.73           7.97
         1.82            6.54           7.37           7.73           8.30
         1.85●           6.60           7.44           7.73           9.19
         3.83            6.66           7.48           7.85          18.18●
         4.44            7.16           7.48           7.87
         5.05            7.20           7.51           7.90
         5.37            7.23           7.54           7.90
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INTER-LABORATORY STUDY      877

POLLUTANT - NO3                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   7

N                   43       RANGE            8.45       C.I.(UPPER)    1.46
TRUE-VALUE         .72       VARIANCE         1.63       C.I.(LOWE  R)     .69
MEAN              1.08       STD. DEV.        1.27       SKEWNESS        4.66
MEDIAN             .86       COEF. VAR.     118.51       ACCURACY       19.44

DATA IN ASCENDING ORDER


       .07             .60              .81              .91              1.28
       .08             .60              .84              .91              1.50
       .16             .66              .85              .94              2.20
       .17             .70              .86              .96              2.48
       .19             .71              .86              .98              2.64
       .20●            .72              .87             1.00              8.52
       .22●            .75              .88             1.06             23.34●
       .50             .75              .89             1.10
       .53●            .80              .90             1.10
       .60             .81              .90             1.15
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INTER-LABORATORY STUDY      877

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                 54      RANGE            7.59      C.I.(UPPER)    2.00
TRUE-VALUE      1.80      VARIANCE          .85      C.I.(LOWE  R)    1.51
MEAN            1.75      STD. DEV.         .92      SKEWNESS        4.73
MEDIAN          1.75      COEF. VAR.      52.53      ACCURACY       -2.78

DATA IN ASCENDING ORDER


      .11          1.61          1.71          1.80          1.94
      .11          1.65          1.75          1.81          1.98
      .85          1.65          1.75          1.82          1.98
      .88          1.66          1.75          1.84          2.01
      .94          1.67          1.75          1.87          2.14
      .99          1.68          1.76          1.88          2.16
     1.28●         1.68          1.77          1.88          7.70
     1.32          1.68          1.77          1.88         18.24●
     1.37          1.68          1.78          1.88         23.40●
     1.40          1.70          1.79          1.90
     1.56          1.70          1.80          1.90
     1.56          1.70          1.80          1.91
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INTER-LABORATORY STUDY      877

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   29        RANGE              .14       C.I.(UPPER)     .05
TRUE-VALUE         .00        VARIANCE           .00       C.I.(LOWE  R)     .03
MEAN               .04        STD. DEV.          .03       SKEWNESS       1.28
MEDIAN             .03        COEF. VAR.       78.54       ACCURACY        .00

DATA IN ASCENDING ORDER


         .01            .02            .03            .06            .10
         .01            .02            .03            .06            .13●
         .01            .02            .05            .06            .15●
         .01            .02            .05            .06          39.00●
         .01            .02            .05            .08
         .01            .03            .06            .09
         .02            .03            .06            .10
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INTER-LABORATORY STUDY      877

POLLUTANT - PB                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  65        RANGE            8.80        C.I.(UPPER)    8.21
TRUE-VALUE       8.40        VARIANCE         2.48        C.I.(LOWE  R)    7.44
MEAN             7.83        STD. DEV.        1.57        SKEWNESS      -3.41
MEDIAN           8.18        COEF. VAR.      20.12        ACCURACY      -2.62

DATA IN ASCENDING ORDER


       .70            7.70            8.10            8.40            8.80
      1.15            7.71            8.11            8.40            8.81
      1.79            7.71            8.12            8.40            8.86
      5.03●           7.71            8.16            8.40            8.89
      5.93            7.74            8.18            8.45            9.00
      7.05●           7.80            8.22            8.46            9.36
      7.14            7.80            8.23            8.47            9.50
      7.20            7.80            8.27            8.48           10.08●
      7.24            7.83            8.28            8.50           10.20●
      7.35            7.88            8.30            8.57           64.20●
      7.47            7.88            8.30            8.64           82.80●
      7.56            7.92            8.30            8.70
      7.56            7.95            8.31            8.70
      7.60            7.97            8.38            8.79
      7.68            8.01            8.38            8.79
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INTER-LABORATORY STUDY      877

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                   61      RANGE          12.17        C.I.(UPPER)  11.14
TRUE-VALUE       11.40      VARIANCE        3.67        C.I.(LOWE  R)  10.18
MEAN             10.66      STD. DEV.       1.91        SKEWNESS      -3.52
MEDIAN           10.96      COEF. VAR.     17.96        ACCURACY      -3.86

DATA IN ASCENDING ORDER


       .62         10.32         10.92         11.36          12.10
      2.76         10.60         10.93         11.40          12.39
      7.27         10.60         10.95         11.43          12.41
      8.45         10.61         10.96         11.45          12.48
      9.36         10.62         10.99         11.46          12.60
      9.54         10.71         11.00         11.50          12.79
      9.60●        10.71         11.00         11.52          13.50●
      9.78         10.78         11.03         11.52         104.04●
      9.85         10.80         11.06         11.52         106.20●
      9.96         10.80         11.07         11.62
     10.10         10.80         11.16         11.63
     10.17         10.87         11.22         11.77
     10.25         10.90         11.25         11.84
     10.32         10.90         11.29         12.00
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INTER-LABORATORY STUDY      877

POLLUTANT - PB                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   7

N                   54        RANGE           14.03         C.I.(UPPER)    4.43
TRUE-VALUE        4.05        VARIANCE         2.64         C.I.(LOWE  R)    3.56
MEAN              3.99        STD. DEV.        1.62         SKEWNESS       4.19
MEDIAN            3.98        COEF. VAR.      40.69         ACCURACY      -1.73

DATA IN ASCENDING ORDER


         .17            3.60            3.90            4.09            4.38
         .64            3.60            3.90            4.10            4.39
        2.79            3.66            3.96            4.10            4.44
        2.96            3.76            3.98            4.10            4.50
        2.98            3.78            3.98            4.14            4.52
        3.10            3.81●           4.02            4.15            5.45
        3.12            3.84            4.02            4.16           14.20●
        3.24            3.84            4.03            4.24           41.04●
        3.24            3.86            4.03            4.24
        3.46            3.89            4.05            4.27
        3.54            3.90            4.07            4.30
        3.60            3.90            4.07            4.31
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INTER-LABORATORY STUDY      877

POLLUTANT - PB
                                   UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -   8

N                   65        RANGE            7.95        C.I.(UPPER)    6.43
TRUE-VALUE        6.60        VARIANCE         1.41        C.I.(LOWE  R)    5.85
MEAN              6.14        STD. DEV.        1.19        SKEWNESS      -3.00
MEDIAN            6.42        COEF. VAR.      19.33        ACCURACY      -2.73

DATA IN ASCENDING ORDER


      .33             5.91             6.37             6.60             6.95
     1.16             6.00             6.40             6.65             6.98
     3.80             6.00             6.40             6.65             7.02
     4.05             6.00             6.42             6.66             7.20
     4.50●            6.00             6.43             6.67             7.44
     4.74             6.00             6.50             6.69             7.50
     5.28             6.00             6.54             6.70             7.74●
     5.31             6.01             6.54             6.70             8.28●
     5.52             6.06             6.54             6.72            48.00●
     5.75             6.12             6.57             6.73            66.00●
     5.79             6.14             6.59             6.73
     5.79             6.24             6.59             6.75
     5.81             6.30             6.59             6.88
     5.88             6.30             6.60             6.89
     5.88             6.30             6.60             6.90
```